RISK MANAGEMENT
IN HEDGE FUNDS

Marius Botha

DISSERTATION SUBMITTED IN
THE CENTRE FOR BUSINESS MATHEMATICS AND INFORMATICS OF
THE NORTH-WEST UNIVERSITY (POTCHEFSTROOM CAMPUS)
IN PARTIAL FULFILMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
MAGISTER COMMERCII (RISK MANAGEMENT).

Supervisor: Professor Paul Styger

London
2005

Aan

Lizl Botha

en

Piet en Barbara Botha

Preface

Much of the theoretical work described in this dissertation was carried out whilst in the employ of Old Mutual Asset Managers in Cape Town, and the Ernst and Young Head Office in London. Some theoretical and practical work was carried out in collaboration with the BWI: University of the North West (Potchefstroom) under the supervision of Professor Paul Styger.

These studies represent the original work of the author and have not been submitted in any form to another University. Where use was made of the work of others, this has been duly acknowledged in the text. Unless otherwise stated, all data were obtained from Bloomberg™ (provider of live and historical financial and economic statistics) as well as Old Mutual Asset Managers (OMAM) internal financial database. Discussions with OMAM portfolio managers and the use of non-proprietary databases provided invaluable insight into current investment trends and obstructions in the hedge fund arena.

The work on the Liquidity Value at Risk was presented at the 57th *International Atlantic Economic Society* conference in Lisbon, Portugal in March 2004 (Botha, van Vuuren and Styger, 2004). This work has been submitted for publication in The AFJ under the heading "Portfolio Liquidity-Adjusted Value at Risk in Hedge Funds".

Work based on previous research, but both necessary and important for the analysis discussed in this dissertation, has been published in *Risk Magazine* (Botha, van Vuuren, 2000), *PJAS* (Botha and van Vuuren, 2001), *The GARP Risk Review* (van Vuuren, Botha and Styger, 2004).

M. BOTHA

Monday, 25 April 2005

Acknowledgements

I acknowledge an enormous debt of gratitude to all that have contributed in some way or other to the completion of this dissertation. In particular, I take special note of the assistance provided – in whatever form – by the people mentioned below:

- Professor Andrea Saayman, Professor Jan van Heerden of the North West University and Ms. Ira Grobler of Standard Bank (South Africa) for comments on earlier drafts of this document,
- my supervisor, Professor Paul Styger, for his patience and prompt feedback,
- my skoonouers, Liza Heystek, vir sy bydrae met taalversorging en vir Ansie Heystek vir haar liefde,
- Martin, Melissa en Jacquelene vir hulle ondersteuning en aanmoediging,
- al my vriende, spesifiek Marisca, Wilanie, John en Wilco vir al die lekker kuier en volgehoue vriendskap en ondersteuning,
- my friend, Barry du Toit, for his valuable insights into the mathematically intractable problems facing hedge fund risk managers, understood by few,
- my mentor, Marc van Veen, for introducing me to the hedge fund world and subsequently teaching me most of what I now know about the field through his extensive knowledge as a superior hedge fund manager. He has proved to be a good friend and a great colleague,
- my friend, Gary van Vuuren, for his willingness to help, technical and mathematical input, proofreading and valuable comments on all drafts of this dissertation. Despite *my* lack of grammatical skills and *his* lack of patience – we remain good friends. He is a loyal friend and a true inspiration,
- my ouers vir hulle ondersteuning, liefde en onophoudelike aansporing. Hul finansiele bydrae tydens my studies, asook die wonderlike voorbeeld wat hulle vir my stel, word opreg waardeer,
- my vrou Lizl Botha vir haar liefde, geduld en ondersteuning deur lang nagte, haar onuitputtende lewenslus en inspirasie.

Abstract

Investing in hedge funds has become very popular in recent years. Previously, their main focus was on the high net-worth investors. These individuals perform their own risk management and they are, according to law, allowed to invest in any asset or product they desire, whilst ordinary citizens and institutions cannot. The focus is now changing as more pension funds are exploring new ways to invest. Hedge funds are realizing this and are currently adapting to accommodate the institutional investors, and they now have to adjust to more regular reporting and more strenuous risk management. This move of hedge funds to institutional investors also requires more risk management to convince the regulators to allow more investors. Regulators still have the event of Long Term Capital Management (a hedge fund that collapsed in 1998, and caused a worldwide market collapse) on their minds. Very strict risk management is required to convince the regulators that pension funds may invest more money in these more sophisticated investment vehicles. Regulators exist to protect the ordinary citizen against optimistic marketing by institutions that will essentially gamble with the not-so-sophisticated investor's money i.e. the man in the street. In this new era of hedge funds, more and better risk management is needed and it is the aim of this dissertation to address these issues. In particular, an improved measure of exponentially weighted moving average volatility, a detailed analysis and solution of the differential scaling in time of risk and return and an empirically-tested enhancement of the incorporation of endogenous liquidity risk into value at risk are presented.

Uittreksel

Die gewildheid van verskansingsfondse het in die jongste aantal jare sterk toegeneem. Aanvanklik was die fokus toegespits op ryk individue wat self verantwoordelik was vir persoonlike risikobestuur. Volgens wet kon hulle belê in enige produk waarin hulle sou belangstel teenoor die gewone publiek en instellings wat nie toegelaat is om tot hierdie fondse toe te tree nie. Die klem het egter nou verskuif na pensioenfondse wat ook nuwe metodes ondersoek om in hierdie fondse te belê. Beleggersfondse het hierdie verandering begin besef en het reeds begin aanpassings maak om institusionele investeerders te akkomodeer. Meer gereelde rapportering en strenger risikobestuur het egter nou krities geword. Pensioenfondsreguleerders verwag beter risikobestuur en poog veral om investeerders te beskerm teen verliese. As gevolg van die 1998 insident bekend as, "Long Term Capital Mangagement", 'n verskansingsfonds wat wêreldmarkte ineen laat stort het, word die risikobestuur van veral gekompliseerde investeringsfondse deesdae baie strenger gekontroleer. Die reguleerder is ook daarvoor verantwoordelik om die gewone publiek te beskerm teen instellings wat onreëlmatige risiko's neem. Daar is bevind dat die toepassing van gevorderde risikobestuurstelsels essensieel is vir die bestuur van verskansingsfondse en dit is dus ook die fokus van hierdie verhandeling. Besondere klem word gelê op verbeterde metingsmetodes van eksponensieel geweegde volitaliteite. 'n Gedetaileerde analise en oplossing van die wyse wat risiko's en opbrengste ontwikkel oor tyd asook 'n empiriese toets om endogene likwiditeidsrisiko te inkorporeer ten opsigte van die waarde op risikometing, word voorgehou.

Table of Contents

PREFACE III

ACKNOWLEDGEMENTS IV

ABSTRACT V

UITTREKSEL VI

TABLE OF CONTENTS VII

LIST OF FIGURES XI

LIST OF TABLES XII

CHAPTER 1 INTRODUCTION 1

1.1. INTRODUCTION 1
1.2. PROBLEM STATEMENT 6
1.3. AIMS OF STUDY AND DISSERTATION OUTLINE 7
1.4. METHODOLOGY 7
1.5. CHAPTER EXPOSITION 8

CHAPTER 2 BACKGROUND TO HEDGE FUNDS 10

2.1. INTRODUCTION 10
2.2. HEDGE FUND DEFINITION 10
2.3. HISTORICAL DEVELOPMENT OF HEDGE FUNDS 11
2.4. HEDGE FUND INVESTORS 12
2.5. FUND MANAGEMENT STYLE 14
2.6. RISK, LEVERAGE AND PERFORMANCE 16
2.7. CURRENT STATUS OF HEDGE FUNDS 19
2.7.1. Hedge fund industry in South Africa *19*
2.8. OVERVIEW OF DIFFERENT HEDGING STRATEGIES/STYLES 20
2.8.1. Event driven *21*
2.8.2. Fund of funds *22*
2.8.3. Global *22*
2.8.4. Global macro *23*
2.8.5. Long only leveraged *23*
2.8.6. Market neutral *23*
2.8.7. Sector *25*

2.8.8. Short sellers ... 25
2.8.9. Managed futures ... 26
2.8.10. Conclusion: hedge fund strategies/styles ... 26
2.9. REGULATION OF HEDGE FUNDS IN SOUTH AFRICA ... 28
2.10. CONCLUSION ... 30

CHAPTER 3 PERFORMANCE MEASUREMENT ... 31

3.1. INTRODUCTION ... 31
3.2. CALCULATING RETURNS ... 31
3.3. HEDGE FUND VALUATIONS ... 33
3.4. PERFORMANCE RATIOS ... 38
3.4.1. Standard deviation ... 39
3.4.2. Sharpe ratio ... 41
3.4.3. Sortino ratio ... 43
3.4.4. Information ratio ... 44
3.4.5. Drawdown ... 45
3.4.6. Scaling problems with risk and return ... 46
3.4.6.1. Scaling up ... 48
3.4.6.2. Scaling down ... 52
3.4.6.3. Scaling problems affecting ratio's ... 55
3.4.7. Funding liquidity risk ... 56
3.5. DISCLOSURES AND TRANSPARENCY ... 59
3.6. HEDGE FUND INDICES ... 61
3.7. CONCLUSION ... 63

CHAPTER 4 RISK MEASUREMENT ... 64

4.1. INTRODUCTION ... 64
4.2. VOLATILITY AND CORRELATION ... 64
4.2.1. Volatility ... 65
4.2.1.1. Simple Moving Average (SMA) ... 65
4.2.1.2. Exponentially Weighted Moving Average (EWMA) ... 66
4.2.1.3. Generalised AutoRegressive Conditional Heteroskedasticity (GARCH) ... 68
4.2.2. Correlations ... 70
4.3. BETA ... 72
4.3.1. Introduction to beta ... 72
4.3.2. Beta: Background information ... 73
4.3.3. Beta as a market exposure tool for hedge funds ... 75
4.3.4. Summary ... 78
4.4. VALUE AT RISK ... 78
4.4.1. Introduction ... 78

4.4.2. VaR calculations ... *78*
4.4.2.1. Historical method ... 79
4.4.2.1.1. Advantages of the Historical method of calculating VaR ... 80
4.4.2.1.2. Problems with the Historical method of calculating VaR ... 81
4.4.2.2. Variance covariance method ... 83
4.4.2.2.1. Advantages of the variance covariance method ... 88
4.4.2.2.2. Disadvantages of the variance covariance method ... 88
4.4.2.3. Monte Carlo simulation method ... 89
4.4.2.3.1. Steps for a single instrument ... 89
4.4.2.3.2. Steps for a multiple instrument portfolio ... 90
4.4.2.3.3. Some issues on Monte Carlo ... 91
4.4.2.3.4. Advantages of the Monte Carlo method ... 96
4.4.2.3.5. Disadvantages of the Monte Carlo method ... 96
4.4.3. VaR literature survey ... *96*
4.4.4. VaR and hedge funds ... *98*
4.5. LIQUIDITY RISK ... 98
4.5.1. Introduction ... *98*
4.5.1.1. Definitions ... 99
4.5.1.2. Literature study ... 100
4.5.2. Liquidity VaR ... *102*
4.5.2.1. Overview of the J&S model ... 103
4.5.3. Portfolio Liquidity-Adjusted VAR ... *105*
4.5.3.1. Methodology and Assumptions ... 105
4.5.3.2. Historical portfolio VaR ... 108
4.5.3.3. La-VaR – "Standard" Method ... 109
4.5.3.4. La-VaR – Using J&S liquidity adjustments ... 110
4.5.3.5. La-VaR – Using J&S liquidity adjustments and an adjusted correlation matrix ... 110
4.5.4. Results ... *111*
4.6. CONCLUSION ... 113

CHAPTER 5 RISK MANAGEMENT ... 114

5.1. INTRODUCTION ... 114
5.2. HEDGE FUND MANAGEMENT PROCESS ... 114
5.3. VOLATILITY AND CORRELATION ... 117
5.4. BETA ... 118
5.5. VAR ... 120
5.6. LA-VAR ... 123
5.7. RISK REPORT ... 124
5.8. CONCLUSION ... 126

CHAPTER 6 SUMMARY, CONCLUSIONS & SUGGESTIONS FOR FUTURE WORK ... 127

6.1. SUMMARY ... 127

6.2. CONCLUSIONS 128
6.3. SUGGESTIONS FOR FUTURE WORK 128

REFERENCES 129

List of Figures

FIGURE 1-1 ANNUALISED HEDGE FUND RETURN VOLATILITY AND ASSETS UNDER MANAGEMENT. 2

FIGURE 3-1 THREE YEARS OF MONTHLY RETURNS WITH $\bar{r}_a = 1\%$ AND $\sigma = 2\%$ 48

FIGURE 3-2 ONE, TWO AND THREE YEARS OF CUMULATIVE MONTHLY RETURNS FOR FIVE DIFFERENT ASSET MANAGERS WITH (A) $\bar{r} = 0$, (B) $\bar{r} = +1\%$ AND (C) $\bar{r} = -1\%$. 51

FIGURE 3-3 ONE AND TWO YEARS OF CUMULATIVE MONTHLY RETURNS FOR 5 DIFFERENT SOUTH AFRICAN ASSET MANAGERS WITH $\bar{r} = 0$ AND $\sigma = 2\%$. 54

FIGURE 3-4 GRAPHICAL EXPLANATION OF THEORY FORMULATED IN THE TEXT. 55

FIGURE 4-1 COMPARISON OF VOLATILITY AS MEASURED BY THE SMA AND EWMA TECHNIQUES. 68

FIGURE 4-2 A COMPARISON OF VOLATILITY CALCULATED USING THE EWMA AND GARCH METHODS. 70

FIGURE 4-3 A COMPARISON OF SMA (OR EQUALLY WEIGHTED- EW) AND EWMA CORRELATION. 71

FIGURE 4-4 PORTFOLIO RETURN AS A FUNCTION OF BETA 74

FIGURE 4-5 SCHEMATIC REPRESENTATION OF THE TWO SOURCES OF ASSET RETURN. 76

FIGURE 4-6 SUMMARY BETA DISTRIBUTION INFORMATION ON PORTFOLIOS OF HEDGE FUNDS. 77

FIGURE 4-7 VECTOR REPRESENTATION OF VOLATILITY. 84

FIGURE 4-8 VECTOR ADDITION WITH CORRELATION BETWEEN VECTORS. 85

FIGURE 4-9 GRAPHICAL VECTOR ADDITION REPRESENTATION OF THREE VECTORS. 86

FIGURE 4-10 COMPARISON OF LA-VAR TECHNIQUES. THE RED TEXT INDICATES ASSUMPTION RELAXATIONS. 107

FIGURE 4-11(A) LONG ONLY PORTFOLIO AND (B) LONG SHORT LA-VAR USING METHOD 1 (HISTORICAL), METHOD 2 (STANDARD VARIANCE-COVARIANCE VAR), METHOD 3 (J&S MODEL) AND METHOD 4 (AMENDED J&S MODEL). 112

FIGURE 5-1 SCHEMATIC SUMMARY OF THE HEDGE FUND MANAGEMENT PROCESS. 116

FIGURE 5-2 ORIGINAL PORTFOLIO BETA AND CORRESPONDING PORTFOLIO WEIGHTS. 118

FIGURE 5-3 ADJUSTED PORTFOLIO BETA WITH CORRESPONDING PORTFOLIO WEIGHTS FOR (A) REDUCED LONG POSITIONS AND (B) INCREASED SHORT POSITIONS. 119

FIGURE 5-4 PORTFOLIO WEIGHTS (A) AND MARGINAL CONTRIBUTION (B) TO VAR. 120

FIGURE 5-5(A) INCREASED VAR AND (B) DECREASED VAR BY INCREASING WEIGHTS AND (C) DECREASED VAR BY DECREASING WEIGHTS. 122

FIGURE 5-6 LA-VAR (MEASURED) AND AFTER RISK MANAGEMENT ADJUSTMENT. 123

FIGURE 5-7 EXAMPLE OF DAILY HEDGE FUND RISK REPORT. 125

List of Tables

TABLE 2-1 BREAKDOWN OF HEDGE FUND ASSETS BY STRATEGY. 27
TABLE 3-1 TABLE 3.1: RESULTS SHOWING THE EFFECT OF LEVERAGE ON THE SHARPE RATIO 42
TABLE 3-2 RETURN AND RISK MEASURED OVER VARIOUS PERIODS. 50
TABLE 4-1 BASIC VAR EQUATION 83
TABLE 4-2 LONG-ONLY PORTFOLIO PARAMETERS. 107
TABLE 4-3 LONG SHORT PORTFOLIO PARAMETERS. 108

Chapter 1

Introduction

1.1. Introduction

"Investors have made a trillion dollar bet that hedge funds will bring them rich returns. But will they?" - *The Economist*, (2005:73)

The fund management industry has been savaged in recent years for its high and opaque fees, deceptive marketing and severe conflicts of interest. At the same time, however, not only has the industry flourished, but it has done so in hedge funds (privately organized, professionally administered, pooled investment vehicles with limited public availability) - its most expensive, highest-leveraged and least-transparent segment. Far from rejecting these unregulated funds, investors have been eager to participate in these markets.

Hedge funds have doubled in both size and number since 2001, whereas mutual funds have only returned to their levels attained in 2000 (Hedge fund research, 2004:1). In addition whilst assets under management have swelled and more than doubled since 1998, overall hedge fund return volatility[1] has diminished by a factor of 3, as shown in Figure 1.1.

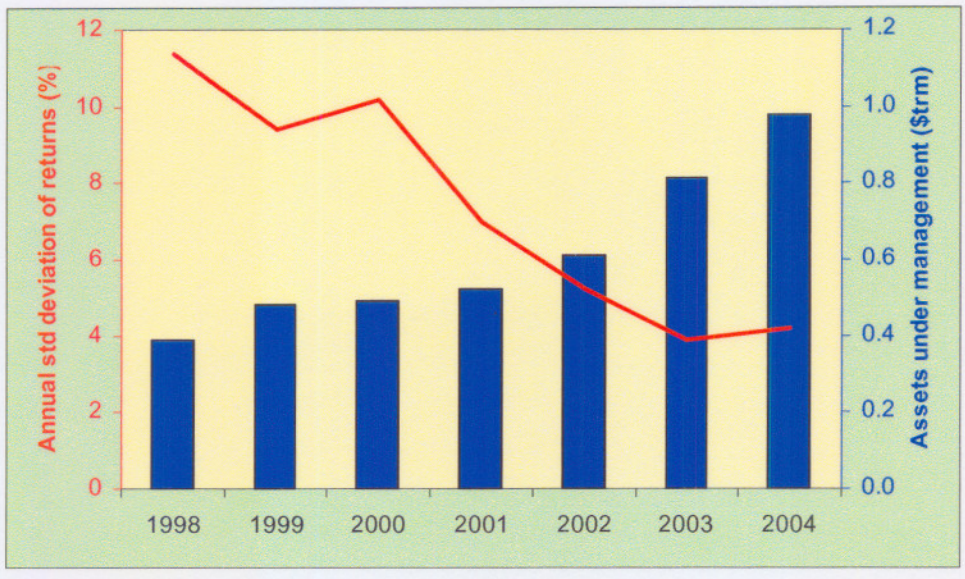
New hedge funds emerge daily in locations varying from home offices to tower buildings. The goal of these amateur entrepreneurs is to build a reliable track record.

Controversial announcements continue to be made that hedge funds will not grow for much longer, but this claim has been made and proved wrong on many occasions and the signs continue to look positive. In addition to continued surging growth in Europe and the United States (US) for example, Arab demands for international hedge funds are expected to grow by 30% in 2005 (Samuelson, 2005:1), Nordic growth in hedge

[1] Volatility (also commonly referred to as standard deviation) may be defined as a measure of price return variability and hence "uncertainty" or risk. This measure is described in Section 3.4.1.

funds by 25% (Hedge Funds World, 2005a:1-2) and Asian hedge fund growth by 50% (Hedge Funds World, 2005b:1).

Figure 1-1 Annualised hedge fund return volatility and assets under management.



(Marks, 2005)

Hedge funds initially attracted only wealthy individual investors. More recently they have begun to attract the attention of large institutions that wish to join in their success. They are therefore expanding at an enormous rate as more investors are lured to invest in them. New York State, for example, announced in January 2005 that a large portion of its $88 billion pension fund will be invested in hedge funds.

Despite the desire to expand further, hedge fund capacity is limited and therefore closed to new investors. Some hedge funds are "soft closed": investors may still invest but only under highly restrictive conditions.

Unlike US mutual funds which are strictly defined under America's 1940 Investment Act[2], hedge funds are currently exempt from this law. Hedge funds operate unregulated almost the world over, including South Africa. This theoretically limits hedge fund interest to the rich and sophisticated investor (see Section 2.3), but in fact, clever

[2] The interested reader may consult Burchell (2004:1) for the full law text of the Investment Company Act of 1940.

lawyers, investment growth and astute marketing have expanded this interest so that anyone can now invest in them.

Hedge funds exhibit the following characteristics:

- they are usually pooled investments (like unit trusts),
- they are structured as private partnerships (unlike unit trusts),
- many carry substantial leverage and are quite rigid about the flow of money from clients, and
- the highly inflexible investment environment, which often includes long – 4 to 5 year lockups – are not uncommon. This provides hedge funds with the opportunity to invest in less liquid assets such as options, futures and other exotic products (The Economist, 2005).

Trading by hedge funds make up more than half the daily volume on the New York Stock exchange; on the JSE this value is approximately 5% (Van Veen, 2005).

Investors value hedge funds' ability to embrace investment opportunities, magnify returns through leverage and take difficult positions because of a stable asset base. But investors have been more conservative in their outlook. Unit trusts, if structured correctly, can have the same characteristics as hedge funds (to some extent, but they might incur liquidity restrictions). When unit trust fund managers attempted investment goals similar to contemporary hedge fund strategies in the 1990s they were accused by consultants and customers of "style drift". They then focused on very specific styles and asset classes such as fixed income or equity funds, following specific benchmarks such as the JSE Top 40 or even a narrower subset such as mid- or small cap indices. Investors realised that the performance of unit trusts mimicked that of the market or sub-sector thereof and thus applied pressure on the fee structure of these products. Many investors decided instead to move their money into index funds because of their cheaper fee structure (Brown *et al.*, 2003:2).

The bear market, which began in 1998, prompted the idea that investment managers knowledgeable of when and where to invest and the freedom to work with a format that allowed them to do so were valuable entities. Allowing fund managers to gener-

ate absolute returns[3] rather than having portfolios follow a specific benchmark, became popular amongst investors.

Relatively good returns, meaning "better performance than the market", have become less important than absolute returns (Brown *et al.*,2003). Institutions now aim to invest in managers that can produce positive alphas (i.e. risk-adjusted returns). Skilled fund managers can, however, produce positive alphas in this new environment, but many find it simpler to start a hedge fund. The fees a hedge fund manager can collect are much higher than those in unit trusts and hedge funds are more flexible. Unit trust fees range from 1% to 2% of assets, whereas hedge funds charge between 1% and 2% of assets under management and a further 20% or greater of profits (Samuelson, 2005). Even these high costs do not completely reflect payment by investors as most hedge funds conduct business through prime brokers who extract fees through share and bond lending charges, as well as trading costs based on the fund's net asset value (NAV).

While unit trust fund managers protest against brokers' high trading costs, hedge fund managers are prepared to pay up to four times this for good ideas or effective execution (Asness, 2004). This makes sense for hedge funds because the hedge fund compensation is tied to outperformance rather than efficiency.

Hedge fund managers constantly seek structured derivatives, margin, stock-lending for short sales and the equivalent for fixed income, clearing and settlement, customer support and marketing – all of which provides opportunities for investment banks. Money generated from these transactions and fees is substantial. Hedge funds were critical to individual firms' performance in 2004 (for example they produced 25% of Goldman Sachs's profits (Bailey *et al.*, 2004)).

Given the spectacular wealth that hedge funds produce for their own managers and for investment firms, they do not, however, produce much wealth for their clients. Highest-performing funds have certainly produced considerable returns[4], but there are

---

[3] Absolute returns: Not losing money, especially when the market falls.

[4] *Renaissance* (a hedge fund in the US) has earned almost 40% annually for more than a decade, *SAC* in excess of 30% (Fild, 2005). There are many others with excellent records.

good reasons to believe that these are rare exceptions. High fees, the ability to attract talent and a performance-oriented incentive structure are all characteristics of hedge funds, but they still face problems.

High fees drag down the performance of most hedge funds. A manager able to outperform the market by a few percentage points per annum is exceedingly rare, yet fees charged for this outperformance do not nearly cover the maintenance of an average hedge fund. High performance fees also encourage the large risks taken by hedge funds, and produce managers who become sufficiently wealthy to retire early and thus lose interest. Managers that perform poorly are quickly removed by disappointed clients. Many hedge funds close voluntarily[5] because earning a performance bonus will require catching up to a prior "high-water mark" (Malkiel & Saha, 2004:3).

The task of selecting a hedge fund that will perform well in the future is a complex task. Indices used to track hedge-fund performance are notoriously unreliable. Hedge fund reporting is erratic; they only report when performance is strong and do not report when performance is disappointing. Some unsuccessful hedge funds never report, whilst hedge fund organisers seed and operate many funds for a few years, and then report only the most successful ones. The worst performing funds disappear completely along with their records[6] (Malkiel & Saha, 2004:2).

Hedge funds of funds (i.e. funds that buy into dozens of other hedge funds, following the "fund of funds" approach that has become common in the private-equity market) perform worse than individual hedge funds because of the double fees they charge. Despite this, such funds remain popular, especially with investment consultants, as they are perceived to be suitable vehicles for risk diversification (Brown *et al.*, 2003:2).

Hedge fund returns, relative to market returns, have begun to diminish. This is true for several reasons:

---

[5] The majority of hedge funds last only a few years.
[6] Only one quarter of the 600 funds that reported data in the US in 1996 still exist (Marks, 2005:2).

- hedge funds tend to hold large cash balances when there is a shortage of trading ideas, but in the current low interest rate environment this affects performance,
- the glut of many hedge funds getting into the business and pursuing identical strategies, and
- the demand for talented fund managers now exceeds supply (Marks, 2005:3).

The biggest area of concern, and one that will almost certainly arise more often in the future, is incorrect valuation of securities held in hedge funds. Securities are, with varying degrees, difficult to price. Diminishing liquidity amplifies these difficulties and hedge funds specialise in illiquid securities. Even if a hedge fund wished to correctly value its portfolio, mispricing is inevitable.

Several recent legal cases in the US have been brought against hedge funds, with damages in excess of $1bn, and involving some 400 funds (AIMA, 2004:12). New regulations, however, are due to come into force in 2006. Hedge funds will have to acknowledge their existence by registering with and submitting to inspection of their books and records by local regulatory institutions. The market expectation is that hedge funds will reprice their assets downwards and also perhaps review how much is charged for compensation.

It remains to be seen whether these new rules will prevent future management abuse or slow the industry's momentum. As hedge funds become ever larger, so the boundary between them and traditional asset management blurs, however, if current investment trends continue, hedge fund assets will soon double to the US$2 trillion mark.

Interest in hedge funds has never been more intense. Investors and regulators are increasing their attention on hedge funds, but for different reasons. One aspect that unites these disparate participants is their view of risk management in hedge funds. This dissertation will focus on this increasingly critical characteristic.

1.2. Problem statement

Hedge fund investment has witnessed increasing popularity for well over a decade. Whilst this was previously the domain of high net-worth individuals, this focus is

changing as pension funds have begun to explore new investment avenues. This shift in focus has now emphasized the need for more regular reporting and more strenuous risk management, and the move of hedge funds to institutional investors also requires more rigorous risk management to satisfy the regulator. Risk management in hedge funds serves not only to diminish portfolio risk, but also, under certain circumstances, to enhance it and thereby increase the probability of higher absolute returns. The measurement of this risk requires a collection of tools and methodologies which, when used in concert, greatly assists the aim of effective risk management.

1.3. Aims of study and dissertation outline

This dissertation covers the history, development and basic characteristics of hedge funds and then explores the unique risks associated with this new type of investment vehicle. In particular this dissertation will focus on hedge fund risk management, with emphasis on risk and return from investors' and fund managers' points of view, fund and asset liquidity and other risk parameters. The wide array of tools and methodologies used to measure and manage hedge fund risk will be described, investigated and applied to South African hedge fund data in order to elucidate the character of these unique risks. Specific methodologies, not previously examined in depth, will also be explored.

1.4. Methodology

All of the data used in this study were obtained from Bloomberg^{TM} (provider of live and historical financial and economic statistics - these data comprised South African equities) as well as Old Mutual Asset Managers (OMAM) internal financial database (these data comprised fund returns, asset allocation weights and portfolio benchmark returns).

The differential scaling of risk and return, described in Chapter 3, is original research conducted by the author. The methodology used to obtain the results presented in this chapter are described in detail in Section 3.4.6.

The methodology pertaining to the time evolution of the exponential decay factor, λ,

and presented in Section 4.2.1.2 is outside the scope of this dissertation, but the interested reader is directed to the work of the author (Botha *et al.*, 2001) where it is described in detail.

Liquidity-adjusted value at risk, detailed in Section 4.5.2, is also original work conducted by the author. The methodology required input data from OMAM databases and is discussed at length in Chapter 4.

1.5. Chapter exposition

The development of hedge funds from their origins in 1949 to the recent surge of interests in the 1990's is traced in Chapter 2. Hedge fund investment styles, regulatory aspects and the psychology behind investing in hedge funds in the current climate of low interest rates and diminishing return-generation opportunities are also reported in this chapter.

Chapter 3 investigates and reports on industry best practice of performance measurement in hedge funds. In particular, various risk-adjusted performance ratios used to characterise hedge fund returns are discussed. The problem of differential scaling in time of risk and return, an important facet of hedge fund reporting, is addressed in this chapter.

Risk measurement methods pertinent to hedge funds are examined in Chapter 4. Common techniques used for this purpose in asset management houses and investment banking are detailed and applied to hedge funds in this chapter. A new technique which accounts for the different unwind periods of portfolio positions is presented. This method, which allows for the calculation of liquidity-adjusted value at risk – a frequently misunderstood and misallocated statistic – is then applied with some good initial success, to a particular clan of hedge funds. Value at Risk (VaR) and other hedge fund risk management parameters such as beta, are also explored in this chapter.

The management of operational and credit risk associated with hedge funds is deliberately omitted from Chapter 5, which focuses instead on the management of the market risk component of hedge funds. A survey of the hedge fund investment process is pre-

sented and the relevant risk management principals are discussed in detail at each stage.

A summary and discussions of the results of this study, as well as the conclusion and suggestions for future research, are then presented in Chapter 6.

Chapter 2

Background to hedge funds

2.1. Introduction

In order to analyse and manage risks in hedge funds, the origin and definition of hedge funds must first be established. The aim of this chapter is to explain when and where hedge funds originated, why they were originally established, describe their constituents and analyse their structure. Several different types of hedge funds will be defined, styles and types of strategies will be explained and the unique type of investor that hedge funds attract (and why) will be discussed. This chapter also focuses on the risk and leverage associated with different types of hedge funds and their regulation by supervisory entities.

2.2. Hedge fund definition

The IMF (2000:78 - 81) asserts that there is no universally-accepted definition of the term "hedge fund", although the expression frequently refers to any pooled investment vehicle that is privately organized, administered by professional investment managers and not widely available to the public. The term *hedge fund* was coined in the 1950's to describe any investment fund that used incentive fees, short selling and leverage (Nicholas, 1999:243). Hedge funds also employ a variety of securities and may use return-enhancing tools such as leverage, derivatives and arbitrage (Hedge World, 2003:1). They offer an absolute return investment objective, defined as a target rate or return that is neither index- nor benchmark-based. The hedge fund manager (i.e. the entity managing the specific hedge fund) will invest in similar asset sectors as traditional investors, but use different skill-based strategies. It is for this reason that hedge funds are often called "alternative investment strategies". Hedge funds are a category *within* the alternative investment environment, and when reference to 'alternative investments' is made, it is not necessarily referring to hedge funds (SA Hedge Fund, 2003:1 and Fischer, 1999:1).

The original model for hedge funds was based on short-selling equities to reduce or eliminate the stock market exposure created by being long other equity securities (Gabelli, 2003:1). If the broad market exposure were neutral, individual security selection (if superior) should provide positive returns. Risk management of these funds is quite different than ordinary funds, and it will be explored further in detail later in this chapter.

More recently, typical hedge funds have begun to employ dynamic (and sometimes opportunistic) trading strategies, which involve taking positions in several different markets and adjusting their investment portfolios frequently (IMF, 2000:78). This allows them to benefit from either an anticipated asset price movement or from anticipated closing or widening of the price or yield differential between related securities (Indjic & Heen, 2003:1). Some securities, however, perform poorly, even in a bull market. Being "long of a security" means that the security is bought with the intention to sell it at a higher price, whereas a hedge fund manager who "short sells" a security will intend to buy it back at a lower price. The component of the investment strategy that is long should outperform in a market rally and the component that is short should hedge in a market sell-off. A hedging strategy is effectively a strategy used to offset investment risk (Downes, 2003:304). The term "perfect hedge" describes the elimination of possible future gains or loss. This means that market risk can be hedged out by being long and short securities that follow the market closely. Through hedging the fund manager aims to achieve positive returns despite the direction of the market. It can be argued that this mitigates market risk (AIMA, 2002:4). This dissertation will explore this risk mitigation, as well as other risks that are unique to hedge funds.

A general description of hedge funds has been outlined. The origins and subsequent evolution of hedge funds will be presented in the next section.

2.3. Historical development of hedge funds

Hedge funds are now widely regarded as effective money-makers for investors. Their evolution will be discussed in this section.

The Investment Partnership set up in the U.S. in 1949 by Alfred Winslow Jones (Landau, 1968:11), which specialized in buying "undervalued" stocks and selling short "overvalued" stocks with the objective of reducing market risk, is widely regarded as the first hedge fund. Jones graduated from Harvard in 1923, toured the world working as a purser on tramp steamers, served as a U.S. diplomat in Germany and then as a journalist during the Spanish civil War. In 1941 he received his PhD in Sociology from Colombia University and became a reporter for *Fortune* Magazine. It was here where he devised the idea of a hedge fund. Whilst working on an article researching the current fashions in investing and market forecasting, he realized he had found a better way of managing money. In 1949 he raised $100 000 ($40 000 of which was his own) and started the first hedge fund, a long short fund (Gabelli, 2003:1).

Since then hedge funds have experienced periods of rapid growth (1966-68, the late 80's and early 90's) and contraction (in 1969-70 and 1973-74). Many hedge funds are highly specialized "niche" players, which rely on the expertise of the management team in a specific area (Hedge World, 2003:2).

Hedge funds have evolved into elaborate investment vehicles since the 1950's. In particular, the last 10 to 15 years have seen phenomenal growth in overall investment size and instrument complexity than anything seen in 1949. This development has also changed the investor viewpoint and is discussed in the following section.

2.4. Hedge fund investors

The changing investment environment and increasing sophistication of investors have also changed the strategies employed by hedge funds. In the US many hedge funds are often registered offshore for tax purposes, but are administered from major cities such as New York and London (Kiyosaki & Lechter, 1997:1). Sometimes, for regulatory or tax-haven purposes, funds are registered in places such as Bermuda. In most countries, hedge funds are exempt from many investors' protection and disclosure requirements and in the US hedge funds are generally structured to be exempt from most regulation. If a fund has less than 100 investors it is exempted from the US Company Act of 1940, and in many cases investors may only invest in a given hedge fund if they are "Accredited investors" (Kiyosaki & Lehter, 1997:246). Hedge funds

are only open to sophisticated investors, high net worth individuals and institutions who are able to assess risks inherent in alternative assets. The Securities and Exchange Commission (SEC) of the US defines an "Accredited Investor as an individual who has:

- $200 000 or more in annual income or
- $300 000 or more in annual income as a couple, or
- $1 million or more in net worth." (Kiyosaki & Lehter, 1997:233)

Hedge funds in the US as well as in South Africa are prohibited from advertising, which explains why there is so little information available to the public: investment is raised via consultants and word of mouth.

Historically, hedge fund investors were high net worth individuals who wished to protect their investments at a desired level of risk. It is important for sophisticated investors to research funds well and undertake good risk management. This is now changing with institutional investors and pension funds increasing their allocation to hedge funds as they seek alternative investments that offer low correlations to institutional portfolios of cash, bonds and equities, thereby reducing the risk of the traditional funds (Brown *et al.,* 1998:1).There has also been a high demand from the retail side. Individuals buy into a hedge fund through a different protocol (individuals can sometimes buy into a hedge fund through some investment structure), but legislation does not allow for these investors as yet. More and more fund of hedge funds are starting up which comprise a number of hedge funds chosen by the fund of hedge funds manager[7] (AIMA, 2002:4).

Rao and Sqilagi (1998:17 - 32) observed that institutional investors were largely absent from the hedge fund industry until the early 1990's. By the end of 1996, nearly 80% of the industry's money came from "accredited investors". The landscape is now changing with institutional investors and pension funds increasing their allocation to hedge funds as they seek out alternative investments (Brown *et al.,* 1998:1).

---

[7] Fund of hedge fund managers allocate funds between different hedge funds.

There seems to be a place for hedge funds as a separate investment class due to their high-adjusted performance and uncorrelated returns with other asset classes. Some financial institutions have exposure to hedge funds via several channels including counterparty trading, derivatives activity, the provision of brokerage services, direct equity investments and direct lending.

Because local and international hedge funds are under few obligations to disclose information, it is difficult to obtain an accurate estimate of the size of the industry. Estimates of the number of funds and total capital under management of hedge funds are based on information voluntarily provided by hedge funds to different commercial data vendors and vary enormously (AIMA, 2002:5). One problem with the voluntary data is that only upcoming hedge funds tend to report results in order to obtain publicity from these data ventures and large funds that are already established do not bother sending updates to vendors. Returns for specific hedge fund strategies vary from vendor to vendor.

The demand for hedge funds has grown and is reflected in the evolving, "different" investor. As an investor, one must decide which style will suite one from both a risk as well as a return perspective.

2.5. Fund management style

Hedge funds are currently lightly regulated (*The Economist*, 2004:71) and unlike other regulated funds, do not have restrictions on the instruments in which they may invest. Thus, it is up to investors who invest in these funds to establish these and decide on an investment style. Unlike mutual funds, hedge funds in general have a typical absolute return target, substantial flexibility in their investment options and management fees that are heavily performance-based (IMF, 2000:78). Although hedge funds do not have too many regulatory restrictions, they often have self-imposed limits set by their own risk management and investment guidelines as well as their commitment to a particular investment orientation outlined in their prospectus.

Fund of funds enjoy two important benefits:

- they are good at establishing sound mandates that manage the risks of unregu-

lated funds and

- they force the fund manager to stick with the agreed investment style (IMF, 2000:78 - 90).

It is, therefore, very important to choose a fund manager who enjoys a good track record and who is consistent with his or her investment style. A manager's investment style is important when choosing between managers; a manager must generate investment returns in the same way as that outlined in his or her investment philosophy. If this is not the case, investors do not experience the exposure that may originally have been agreed upon.

Risk-return profiles of hedge funds are determined by their trading strategies. There are a wide variety of hedge fund styles available in the industry including event driven, global, macro, long-only leverage, short-selling, market-neutral, sector, long short, etc. (MarHedge, 2001:1). These strategies will be discussed in further detail in Section 2.8. Different hedge fund styles have different volatilities and returns. Comparison of the volatility of hedge funds returns with the volatility of returns of mutual funds and benchmark indices yield different results depending on the choice of the sample period. Using data from 1988-1995 for a large sample of existing and defunct funds in the US, Ackerman *et al.,* (1999:45) found that hedge fund returns were more volatile than mutual funds or market indices. By contrast, Edwards (1999:191), found that during 1989-1998, typical hedge fund returns were less volatile than that of mutual funds and market indices. Good hedge fund data are very scarce (e.g. prices, returns, volatilities) and when gathered from different vendors they are frequently inconsistent. No historical data (beyond 7 years) could be found for the South African hedge fund market and no comparison could therefore be made.

There is a tendency for hedge fund managers to lower their leverage – this has the effect of lowering fund volatility, as observed in the later results. Hedge fund managers are becoming more risk averse and desire more consistent returns. Different styles provide the investor with different exposures to different instruments, but within these styles there can be different risks and returns. Leverage, discussed in the next section, is only one of these risks.

2.6. Risk, leverage and performance

Some hedge fund styles use leverage to better their profits, but with increased leverage comes increased risks. Hedge funds obtain their leverage from trade counter parties, which generally allow hedge funds to finance their trades via:

- Futures-only exchange margin requirements. This is the obligation of the parties to fulfil their commitments under an exchange-traded derivatives contract and is secured by margining arrangements (Goodspeed, 2004:23).
- Options-notional amount in contract. This is the option premium one receives or pays to obtain exposure to an underlying security accounts for leverage (Goodspeed, 2004:53).
- Total return swaps. In a total return swap the return from one asset or group of assets is swapped for the return of another. This can be done without the exchange of assets and is structured in such a way that it is initially worth zero (Hull, 2000: 241).

If a security is shorted by a hedge fund, the security is essentially borrowed from another institution and a fee (i.e. a script lending fee) is then payable to the institution. Cash is then received for the sale of that security in the market and may be used to purchase another security in that or indeed another market.

The amount of leverage used by hedge funds largely depends on their trading strategies as well as the type of instruments invested in (determined by the investor's preference and attitude towards risk). Types of leverage used are usually a derivative type in which one is only required to post margins. Leverage used can also differ within the same investment strategy (FSB, 2004:2). There are little reliable data on hedge fund leverage and the accounting-based leverage ratios reported by different data vendors suffer from many shortcomings. For example Managed Account Report (MAR) (MarHedge, 2001:1) requires hedge fund managers to report their maximum potential leverage and, therefore, the actual leverage that a fund uses at any particular time may be smaller than the reported leverage (IMF, 2000:45). However, because the public often associate high leverage with high risk and because hedge funds report to

data vendors that are typically not registered, hedge funds may have an incentive to report lower leverage than what is actually employed.

It is always assumed that the more leverage used the more risk is taken, but managers who use more leverage do not always experience higher volatility and therefore not always higher risk. Indeed, such leveraged funds may sometimes have lower volatility than those managers with lower leverage and it is here that good risk management comes into its own. The variability of the risk being taken depends on the strategy used: higher leverage does not necessarily mean higher risk. A good example is retail investors. Retail investor may, through buying futures contracts, obtain far more leverage than most hedge funds would consider. During the past five years many hedge funds both locally and internationally, have begun to lower their leverage. If the lower leverage persists, the average hedge fund return will be lower than those in the past, but accompanying the lower returns (due to leverage) is a reduction in the volatility of returns (Hedge World, 2003:2). Lower leverage and lower performance might yet affect the risk-adjusted performance.

Evaluating the risk-adjusted performance of hedge funds is difficult because of their dynamic trading strategies (Shewer *et al.,* 2003:10). Further, because of the short time series of hedge funds returns, conclusions about their past (and by some accounts, superior) risk-adjusted performance must be treated with caution. Nevertheless hedge funds may provide substantial diversification benefits because their returns typically have relatively low correlation with standard asset classes. By some accounts, hedge funds may also be used for downside risk management[8] due to the low correlation they have to other asset classes.

A desirable property of any active strategy is that it offers returns over and above that which can be achieved by exposure to passive buy and hold investments. This additional return is sometimes referred to as alpha (α). As many hedge fund strategies seek to hedge out market risk, the systematic risk is small because of the low correlation to the market and the diversifiable or idiosyncratic risk is high. Because of this low systematic risk, most of the returns account for α. It is still unclear whether for

[8] Downside risk, is the risk of loosing money when the market decreases.

hedge funds, α is relevant (beta (β) represents systematic risk and α the diversifiable risk) (Peskin *et al.*, 2000:2).

Hedge funds share many risks common to most financial markets (such as market risk, sector risk and security-specific risk, liquidity risk, herd risk, operational risk), but there are also some risks that are unique to hedge funds, as many of them arise from the short positions they take. These include counter-party risk, borrowing risk, credit-crunch risk and concentration risk (Long Term Capital Management (LTCM[9]) would have had to sell – in one transaction – an amount which represented multiple days' total volume for some markets, under normal market conditions. This would have had to be undertaken simultaneously in many markets (Lowenstein, 2001:32)).

The question that arises is: how do hedge funds differ on a risk/return basis from traditionally managed funds? The answer is: in a number of ways, but the two most significant are:

- **Risk:** Most hedge fund managers define risk in terms of potential loss of invested capital whereas traditional active managers define risk as the deviation (tracking error) from a stated benchmark (Shewer, *et al.*, 2003:13). The risk associated with hedge funds is therefore highly dependant on the skills of the individual manager both in implementing the chosen strategy successfully and in the running of their business (AIMA, 2002:32).
- **Return:** Hedge fund managers aim to deliver a total return unrelated to a benchmark or index that is therefore independent of the general direction of markets. A traditional active manager largely aims to deliver relative returns (returns above a related benchmark). This relative return may also be negative if the benchmark return is negative. Therefore the generation of returns by hedge funds is reliant on the skill of the manager, whereas traditional strategies primarily reflect the return of the underlying asset class (AIMA, 2002:6).

Note on these points that the return of the traditional manager and the benchmark are highly correlated because of the tracking error and the standard deviation of returns

---

[9] LTCM was a hedge fund in the late 1990's that collapsed because of liquidity problems on the very high leveraged funds that they managed (Lowenstein, 2001:84).

will be more or less the same. Hedge funds, because of their absolute return nature, have very low correlation with traditional fund managers and usually have a lower standard deviation of returns due to hedging (Peskin *et al.*, 2000:4).

Hedge funds are perceived as being more risky due to the leverage they employ. This is not always the case as they often have higher leverage, higher returns, but a *lower* risk. The current status of hedge funds now in the world and specifically in South Africa will be discussed in the next section.

2.7. Current status of hedge funds

Hedge funds are widely perceived as being risky investments, but this is an unfair perception. Historically, hedge funds have enjoyed – for the most part – higher returns and lower risk than long only funds. LTCM left the hedge fund industry with a risky reputation, but the Russian crisis and the near-failure of LTCM caused only a temporary outflow of capital from the hedge fund industry (Asness *et al.*, 2001:3). Hedge funds have been popular with high net worth individuals and endowments traditionally, but many hedge funds have recently experienced an increase in interest from a broad range of institutional investors. Industry observers also report that in response to increased investors interest, some investment banks have been setting up hedge funds within their asset management groups, while at the same time reducing their proprietary trading activity (Asness *et al.*, 2001:3). Looking ahead, it is likely that investors will try to diversify their holdings across more hedge funds (keeping in mind the lesson of LTCM), which will probably stimulate the growth of funds of funds. Some industry observers also point to signs of greater differentiation within the hedge fund industry, with some hedge funds becoming more liquid and reducing their minimum initial investment and other funds increasing their lockup periods and lowering redemption frequency. Both banks and investors will monitor hedge funds' leverage levels more closely than in the past (Asness *et al.*, 2001:3).

2.7.1. Hedge fund industry in South Africa

The hedge fund industry is also growing in South Africa with some funds that have been around for periods longer than three years and enjoy good performance track

records. Most investors expect to see track records before they will invest capital in a new fund. Others that do not enjoy long track records continue to trade on seeding capital in the attempt to build up track records and attract some external capital. Fund of funds require track records in order to analyse fund manager capabilities. Without these data, very few fund of funds would invest in a newly started hedge fund, but with time, smaller funds are accumulating longer track records and the industry is growing (Asness *et al.,* 2001:4). Hedge funds in South Africa will most probably obtain more capital from pension funds, i.e. will be allowed to invest a small portion of their funds in hedge funds, as they are seeking an uncorrelated investment to traditional asset classes. Another factor that would generate capital inflow coming into the hedge fund market would be if foreign exchange controls were lifted. It is clear that the hedge fund community is growing, and not only in South Africa.

The hedge fund industry in South Africa has an excess of R50bn under management, comprising around 60 funds (Shames, 2004). This has grown significantly in the last five years as more funds are being recognised. Only about ten funds constitute the majority of the industry and the rest continue to build a track record. A large proportion of the South African hedge fund market comprises long short equity funds (see next section), in contrast to the situation encountered in most other countries. The South African market is smaller and less developed and this has prevented the expansion and development of other strategies. Although other strategies are found in South Africa, they are usually small; approximately 80% of the market comprises long short strategies (Taljard, 2004).

Some of the different worldwide strategies will be explained in the next section.

2.8. Overview of different hedging strategies/styles

Style is a widely used term used to categorize a hedge fund's investment orientation. Among the terms often used to describe conventional investment funds are "aggressive" and "growth" and "growth-and-income" – but all these terms describe the fund's *return* objective. A hedge fund style classification tends to be much more descriptive of the *markets* in which the manager invests (MarHedge, 2001:1). With different

styles come different risks (explained later in this dissertation), although most of the focus will be on the long short strategies.

Little consensus exists on hedge fund styles. A style classification should only exist when a statistically significant number of funds fit the heading (MarHedge, 2001:1). Although there is more than one definition and description for different styles, in this dissertation MAR/Hedge[10] styles will be used as a basis and other descriptions will be described relative to this. The rest of this section will focus on the different styles.

2.8.1. Event driven

Event-driven investment themes are dominated by events or special situations or opportunities to capitalise from price fluctuations. Event driven styles can be divided into:

- **Distressed securities:** The hedge fund focuses on securities of companies in reorganization and/or bankruptcy ranging from senior secured debt (low risk) to common stock (high risk) (Barra Rogerscasey, 2001:11). The liquidation of a financially distressed company is the main source of risk in these strategies, or the incorrect assessment of information regarding the company's finances and potential for improved profitability (Owens, 2003:4 and SA Hedge Fund, 2003:3).

- **Risk arbitrage:** The hedge fund manager simultaneously buys stock in a company being acquired and sells stock in its acquirers. If the takeover falls through, traders can be left with large losses. The risk associated with such strategies is more of a "deal" risk rather than market risk (Owens, 2003:4 and AIMA, 2003:9).

The risk in these strategies is non-realisation of the event.

[10] MAR/Hedge is a US institution that combines different hedge funds into an index.

2.8.2. Fund of funds

Investors' capital is allocated by the hedge fund manager among different hedge funds with different strategies and styles, as well as pooling investors' money together. This enables access to managers with higher minimum investments than individual investors could afford (MarHedge, 2001:1). Two types of fund of funds exist, namely a *diversified fund* that allocates capital to a variety of fund types and a *niche fund* that allocates capital to a specific type of fund (SA Hedge Fund, 2003:3 and Barra Rogerscasey, 2001:11).

2.8.3. Global

- **International:** The hedge fund manager pays attention to economic change around the world except in the home country. He will invest money in countries he feels comfortable with in conjunction with a reasonable amount of risk. This is usually a bottom-up approach and managers tend to be stock pickers in markets they like (MarHedge, 2001:1). Hedge fund managers can have stocks across different markets at any time.

- **Regional – Emerging:** The hedge fund manager invests in less-mature financial markets. These less-mature markets are perceived to have more opportunities, but more risk. In addition, shorting securities is not permitted in some emerging markets. Because shorting is not permitted in many emerging markets, managers must revert to cash or other markets when valuations make being long unattractive (Owens, 2003:4). The focus here is on specific regions, in which they can allocate their money to invest (MarHedge, 2001:1).

- **Regional – Established**: The hedge fund manager focuses on opportunities in established markets and allocate capital between these markets. The hedge fund manager may seek opportunities in the US, Europe and Japan: the so-called US opportunity, European opportunity and Japanese opportunity (MarHedge, 2001:1). The hedge fund manager shifts money between these already developed markets to the best potential opportunity.

2.8.4. Global macro

This is an opportunistic type of hedge fund manager who will profit from opportunities, wherever value is observed. Leverage and derivatives are used to enhance positions, which will have different time frames from short term trades (less then one month) to long term trades (more than 12 months) (MarHedge, 2001:2). The aim of Global Macro is to profit from changes in global economies, typically based on major currency and interest rate movements due to shifts in government policy (Owens, 2003:1). A Global Macro manager invests money into countries that he believes will prosper, and sell those investments in countries that he believes will do poorly relative to other countries.

2.8.5. Long only leveraged

Traditional equity funds are structured like hedge funds in the sense that they are strategies which employ a growth or value approach to investing in equities with no short selling of equities, or hedging to minimize inherent market risk. Long only leveraged funds, however differ from traditional equity funds in that they take on leverage to enhance their returns (MarHedge, 2001:2). These funds mainly invest in emerging markets where there may be restrictions on short sales. This gives the manager the right to use leverage and collect incentive fees (AIMA, 2004:12). Long-only leverage funds deliver absolute returns without short selling and make use of leverage through various ways.

2.8.6. Market neutral

Here, hedge fund managers attempt to lock out market risk or neutralize market risk through hedging these securities that are correlated to the market. These methods will be explained in this section.

In theory market risk is greatly reduced with this strategy, but it is difficult to make a profit on a large diversified portfolio, therefore the ability to choose stocks is critical (Owens, 2003:1). In market neutral strategies there are some hidden risks (SA Hedge Fund, 2003:3). The different risks involved and the neutrality of these strategies are discussed in Chapter 4. Different types of market neutral strategies are:

- **Long short:** In these funds, returns are generated through buying equities at low prices and selling them at higher prices. This results in a long exposure of the fund. The short exposure of the fund occurs when equities are sold at high prices and then later bought back when prices have decreased. When the long and short exposures are combined in the fund, a net exposure results. For example, if one has R100 worth of equities on the long side and R80 of equities on the short side, the net exposure is (R100 – R80 = R20).

  Net exposure to market risk is reduced by having equal allocations on the long and short side of the market, i.e. a net exposure of zero. This does not necessary mean, however, that all market risks are eliminated, although this is often assumed (see Chapter 4). The portfolio may also be long-biased[11] or short-biased[12] and, thus, the portfolio returns will not be completely independent of market movements. The risks in this strategy arise from the stock specific risks of the long and short positions. These are also called equity hedge funds (Assness *et al.*, 2001:11).

- **Convertible arbitrage:** This is one of the more conservative styles. The hedge fund manager buys convertible securities of a specific company and sells the underlying equities of that same company, profiting from mispricing in the relationship between the convertible bond and the equities. He may use low or high levels of leverage depending on the amount of leverage the hedge fund manager is allowed to take as well as his level of comfort (Barra Rogerscasey, 2001:10 and Owen, 2003:2).

- **Stock arbitrage:** The hedge fund manager buys a basket of stocks and sell short stock index futures contract, or vice versa. The hedge fund manager then profits from the arbitrage opportunities between the index and the basket of stocks.

- **Fixed income arbitrage:** The fixed income arbitrageur or hedge fund manager aims to profit from price anomalies between related interest rate securities

---

[11] Long biased occurs when the net exposure of the fund is positive, having more exposure on the long side than on the short side.
[12] Short biased occurs when the net exposure of the fund is negative, having more exposure on the short side than on the long side.

(Barra Rogerscasey, 2001:13). The hedge fund manager purchases bonds, often Treasury bonds (but also sovereign and corporate bonds), and goes short of instruments that replicate the owned bond. The hedge fund manager aims to profit from incorrect pricing of the relationship between the long and short sides. Most managers trade globally with a goal of generating steady returns with low volatility. This category includes interest rate swap arbitrage, US and non-US government bond arbitrage, forward yield curve arbitrage, and mortgage-backed securities arbitrage. The mortgage-backed market is primarily US based, over the counter and particularly complex (Barra Rogerscasey, 2001:13). The risk in these bonds varies depending on duration, credit exposure and the degree of leverage (Agarwal & Naik, 1999 and MarHedge, 2001:2). These risks will be explained in Chapter 4.

2.8.7. Sector

The hedge fund manager follows specific economic sectors and/or industries. Money is invested in sectors believed to be increasing in value, and sectors that are believed to be losing value are short sold. Managers can use a wide range of methodologies (such as bottom up, top down, discretionary, technical[13]) to determine the sector or industry in which to invest (MarHedge, 2001:2).

2.8.8. Short sellers

The hedge fund manager takes the position that stock prices will decline. A hedge fund manager borrows stock and sells it, hoping to buy it back at a lower price. Only overvalued securities are shorted. This is a hedging strategy for long only portfolios and those who feel the market is approaching a bearish trend. This is sometimes also referred to as "short bias" and a sub sector of a long short strategy according to some definitions (AIMA, 2002:14).

---

[13] These investment methodologies, used to determine which instruments or sectors to buy and sell, are focused on determining the value of those instruments and not on risk management. They therefore fall out of the scope of this dissertation.

It is true that some institutions separate a long short portfolio with short bias from short sellers. The reasoning behind this is that short sellers are only allowed to sell short securities whereas a short bias can mean that the hedge fund only has more short securities than it has long securities (MarHedge, 2001:2).

2.8.9. Managed futures

"Managed futures" is not a MAR/Hedge style. The CSFB/Tremont (L'habitant, 2001:2) styles are in line with the MAR/Hedge styles except for an addition of managed futures. Managed futures hedge funds trade in listed financial and commodity future markets and currency markets around the world. This strategy is based on speculation of the direction in the market prices of currencies, commodities, equities and fixed interest and on spot or futures markets across the globe. The managers are usually referred to as Commodity Trading Advisors, or CTAs. Trading disciplines are generally systematic or discretionary. Systematic traders tend to use price and market specific information (often technical) to follow trends while discretionary managers use a less quantitative approach, relying on both fundamental and technical analysis (Barra Rogerscasey, 2001:13).

2.8.10. Conclusion: hedge fund strategies/styles

Non-directional strategies such as market neutral, event driven, etc., that have little market exposure have in general higher Sharpe ratios[14] (see Chapter 3) and lower downside risk as compared to directional strategies (the Sharpe ratio is discussed in greater detail in Chapter 3, along with several other performance measurements). These non-directional strategies, due to their low market risk, are good vehicles for other funds to diversify their current exposure (Barra Rogerscasey, 2001:13). The trends in the capital markets support a favourable outlook for hedge funds going forward, and show how hedge funds can enhance strategic asset allocation for both pension funds and endowment funds. This is due to their low correlation with traditional asset classes, (Peskin *et al.*, 2000:5).

---

[14] Sharpe ratio: The Sharpe ratio's numerator is portfolio return less the risk-free rate. The Sharpe ratio's denominator is standard deviation of portfolio returns (Sharpe, 1994:49).

Table 2-1 below shows a breakdown of the amount invested in the different strategies for the US (Barra Rogerscasey, 2001:9).

The long short strategy is the most popular hedge fund strategy, followed by Global Macro. Long short funds in South Africa in 1992 comprised 92% of the total hedge fund universe, but this has decreased to about 83% in 2003 (Shames, 2004). This suggests that there is a demand for more exotic products in South Africa. Other strategies such as event driven, statistical arbitrage and long only leverage are on the increase.

Table 2-1 Breakdown of hedge fund assets by strategy.

Convertible arbitrage	4%
Distressed securities	3%
Regional – emerging	3%
Long short	31%
Equity market neutral	5%
Equity non-hedge	11%
Event driven	9%
Fixed income arbitrage	8%
Global Macro	15%
Risk arbitrage	2%
Relative value arbitrage	3%
Sector	5%
Statistical Arbitrage	1%

(Barra Rogerscasey, 2001:9).

So far the history and development of hedge funds, hedge fund investors, different styles and strategies as well as risk and leverage has been discussed. A brief explanation of regulation of hedge funds in South Africa is now presented.

2.9. Regulation of hedge funds in South Africa

Hedge funds fall into the category of alternative investments (although this is a separate category within the alternative environment). A problem faced by the Financial Services Board (FSB, 2004:35) in South Africa is the definition of hedge funds. Although the definition of hedge funds and the different strategies has already been discussed in this Chapter it is important to define them from a regulatory point of view.

Hedge funds have been historically associated with unregulated or privately organized investment schemes for the wealthy. There are numerous hedge fund styles and strategies as shown in the previous Section. Even different databases have different strategies that hedge funds fall into making regulation particularly difficult (SA Hedge Funds, 2003:1).

The International Organization of Securities Commission (IOSCO) has defined hedge funds as the following (IOSCO, 2003:56):

A hedge fund has at least some of the following characteristics:

- borrowing and leverage restrictions, which are typically included in collective investment schemes in which regulations are not applied, yet many (but not all) hedge funds use high levels of leverage. Therefore a fund that borrows securities or uses leverage is defined as a hedge fund,
- significant performance fees (often in the form of a percentage of profits) are paid to the hedge fund manager in addition to an annual management fee,
- investors are typically permitted to redeem their interest on their investment only periodically, e.g. quarterly or semi annually,
- often significant "own" funds are invested by the manager,
- derivatives are often used for speculative purposes and there is an ability to short sell securities,
- more diverse risk or complex underlying products are involved (FSB, 2004:35).

There are many other definitions of hedge funds, defined by different people from dif-

ferent countries. All are quite similar, but there is no single definition. In order to regulate a product one must have a definition of the product.

According to a joint discussion paper by the Financial Services Board (FSB), Association of Collective Investments (AIMA, 2004:5) and Alternative Investment management Association (AIMA, 2003:7) there are common characteristics of all the different definitions:

- the funds use some sort of short asset exposures or short selling, to reduce risk or volatility, preserve capital or enhance returns,
- the funds use some form of leverage, measured by gross exposure (long securities plus short securities) of underlying assets exceeding the amount of capital in the fund. There is more than one definition of leverage and
- the fund managers charge a fee based on the performance of the fund relative to an absolute return benchmark such as inflation or call interest rates (FSB, 2004:10).

Currently in South Africa, the Financial Advisory and Intermediary Services Act (FAIS) regulations do not provide specific guidance regarding the marketing and selling of hedge funds (FSB, 2004:9). Currently, domestic hedge funds are not regulated. Under the collective investment schemes, offshore hedge funds would not be allowed to market themselves in South Africa, because hedge funds in general are not allowed to market themselves, the FSB would not approve of any hedge fund for marketing purposes. As mentioned earlier, hedge funds in South Africa are not allowed to market themselves to the public, therefore most hedge funds market themselves to sophisticated investors, through partnerships trusts, etc., (IOSCO, 1999:32).

Hedge funds in South Africa make use of leverage and short selling and it is because of this leverage that they have higher systematic risk. This risk and the lessons of LTCM have ensured that hedge funds are only open to the sophisticated investor prepared to take these risks for the possibility of obtaining higher returns.

The regulator therefore aims to:

- ensure that the activities of hedge fund managers are appropriately regulated,

- obtain a better understanding of the demand for creating a regulated product structure of structures aimed at accommodating hedge funds and
- clarify the rules governing the marketing and selling of hedge funds to both sophisticated and retail investors (FSB, 2004:4).

Hedge funds in South Africa are currently unregulated and may therefore invest in any asset or derivative type they choose. The regulator, therefore, must look at the types of underlying assets in which hedge funds invest, leverage short selling derivative structures etc., before hedge funds may be regulated (Polyn, 2001:12). Unregulated hedge funds will be marketed to only high net worth individuals and therefore do not need to be regulated in any way. On the other hand, regulated hedge funds will cater for more institutional and retail investors and the fund and fund manager will have some restrictions enforced upon them. In the case of an unregulated fund it is the investor that must ensure that there are proper risk management processes in place.

2.10. Conclusion

This chapter presented a brief history of the hedge fund industry, explaining their origins, subsequent development and strategies employed. In addition, investors in these funds and the South African regulations which control hedge funds – however scant at the moment – were also discussed. With this overview in place, Chapter 3 will now discuss best practices currently employed for hedge fund performance measurement.

Chapter 3

Performance measurement

3.1. Introduction

The origins and subsequent development of hedge funds were discussed in the previous chapter. In addition, the evolution from simple long short funds into more elaborate investment vehicles was presented.

The principal reason for investing in hedge funds, as with any fund, is to earn returns at a return greater than the risk-free rate, though the investment process of the fund. Returns are the most widely reported statistics pertaining to any investment. If an investor is able to tolerate the risks associated with the generation of a fund's return, it is the only measure that matters (Lake, 2004: 241).

In this chapter the way in which these returns are calculated and reported will be examined as well as – more importantly – the revelations these returns indicate about the riskiness of the fund. Several ratios assist with these aims and these will also be explored in this chapter, along with potential pitfalls involved in the calculations.

3.2. Calculating returns

The return on any investment is an important measure that is reported to investors. Grinblatt and Titman (1998:106-111) define *return* as the profit per quantity invested. The rate of return is given by Equation 3-1 below:

$$r = \frac{P_1 + D_1 - P_0}{P_0} \qquad \text{3-1}$$

Where

r = rate of return in decimal format,

P_1 = end of period value of the investment,

P_0 = beginning of period value of the investment and

D_1 = cash distributed over the period.

In this case, if an investment, say a share, were bought at price P_0 (R8), a dividend of D_1 (R1) was received during the investment period and the share was sold for price P_1 (R10), this would result in a long position in the portfolio and a return of 37.5%, using Equation 3-1.

If this share were incorporated in the portfolio as a short position it would have made a loss, and the equation would be slightly different as indicated in Equation 3-2:

$$r = \frac{P_0 - P_1 - D_1}{P_0} \qquad \textbf{3-2}$$

In this case, if a share was sold at price P_0 (R8), a dividend of D_1 (R1) were paid to the institution from whom the share was borrowed, and it was bought back for a price of P_1 (R10), this would result in a short position and a return of -37.5% for the portfolio, using Equation 3-2.

Consider the case in which a portfolio comprises three shares, a, b, and c, with investment weights w_a, w_b, w_c and returns of r_a, r_b, r_c. The overall portfolio return is given by, $w_a r_a + w_b r_b + w_c r_c$ giving a total portfolio profit or loss. This may also be expressed as a percentage of the fund value, or capital invested. The risk that the investor faces, then, is whether or not the returns have been correctly calculated and what fees are based on this calculation.

The accepted methodology of calculating "average" returns is to use the geometric mean[15] because it involves compounding of the returns – or calculation of interest on interest. This is widely considered to be the best assumption (Lake, 2004:246) unless the gains (profits) are withdrawn on a regular basis. Suppose a portfolio has a value

---

[15] The geometric mean of T returns, $r_1, r_2 \ldots r_T$ is

$[(1 + r_1) \times (1 + r_2) \times \ldots \times (1 + r_T)]^{1/T} - 1$ (Grinblatt & Titman, (1998:106-111).

of R1 000 in year 1, a value of R2 000 in year 2 and a value of R1 000 in year 3. The beginning and the end value are the same, which implies a return of 0%.

When calculating arithmetic return, an annual return of 25% is obtained. This comes from year 1: $\left(\frac{2000-1000}{1000}\right)=100\%$, year 2: $\left(\frac{1000-2000}{2000}\right)=-50\%$, arithmetic sum equals 50% over two years hence arithmetic average over one year equals 25% per annum. Using the geometric mean gives a value of 0%. This is obtained from $(1+100\%)(1-50\%)-1=0\%$. This is because the geometric mean accounts for the affect of compounding whereas the arithmetic return does not (Lake, 2004: 248).

The calculation of fund returns was described in this section. Pricing of individual components of hedge fund portfolios is non-trivial, and this complex practice is presented in the next section.

3.3. Hedge fund valuations

Returns are important to investors for several reasons. Not only do returns reflect the amount of money generated, they also provide a great deal of information for the investor. VAN Hedge Fund Advisors International (2000:4) report the following comment heard during a seminar in 1995: "You just can't tell how a hedge fund will perform from its past performance". The individual concerned had been heavily invested in Macro funds in 1994 – a bad year for hedge funds. Macro funds, however, performed spectacularly between 1989 – 1994 (VAN Hedge Fund Advisors International, 2002:1). Past returns do indeed not predict future returns, but they do provide valuable information about the funds, for example volatility, embedded correlation, fund manager style and risk appetite.

In predicting the future state of the world, a statistic is only as useful as:

- the extent to which it measures that which it purports to measure and
- the extent to which the future replicates the past (VAN Hedge Fund Advisors International, 2000:5).

More measures will be examined later in this Chapter that will portray information about returns. These measures give additional information about the returns and the characteristics and risk of hedge funds.

There are only a few factors that actually affect hedge fund performance (VAN Hedge Fund Advisors International, 2000:6). The list below details some factors that affect performance.

- **Style:** The hedge fund investing style used, this has been discussed in Chapter 2. This is an important element as some styles appear to have more up-side than others.

- **Asset Class:** The asset class could encompass any asset, for example, stocks, futures and bonds or any combination thereof.

- **Risk Controls:** The quality and type of risk control used are significant determinants of hedge fund performance. A manager who fights these controls and insists on being significantly short in a "raging bull market" is using bad judgment and weak technique compared to his peer who rides the market up, and, for downside protection, uses relatively inexpensive out-of-the-money puts.

- **Leverage:** The extent of leverage can help or hinder returns, depending on whether or not the manager's bets are correct.

- **Portfolio Concentration**: The degree of portfolio concentration, like leverage, will enhance or diminish returns depending on the accuracy of the manager's bets.

- **Market Sector:** The market sector invested in can produce superior returns, particularly for long-biased managers in up-markets.

- **Fund Size:** The topic of fund size and its influence upon performance, is interesting to hedge fund observers who have seen first hand the earnings struggles of funds that have grown rapidly. In recent years, some of the largest funds have slowed their growth by returning money to investors. There has been no rigorous evidence that demonstrates that fund size adversely affects performance

(VAN Hedge Fund Advisors International, 2000:6).

Every hedge fund manager has size limitations, based on several factors (VAN Hedge Fund Advisors International, 2000:2):

- **The ability to build and manage an organization**. This causes some hedge fund managers to fail at a relatively early stage.

- **Trading style**. Clearly, a macro or opportunistic manager who trades in bonds and/or currencies has more capacity than a micro cap or distressed securities manager who makes niche investments.

- **Willingness to delegate trading decisions to subordinates**. The Soros and Robertson organizations continue to thrive with numerous managers running different segments. A number of other well-known global traders who insist on "pulling the trigger" themselves have experienced size limitation.

- **The velocity of growth:** This is as great a challenge as absolute size. The manager whose fund grows from R200 million to R800 million in one or two years is likely to have performance problems.

When considering performance it is always better to look at a rolling twelve month period, to observe when returns were the worst and when the best (Lake, 2004:243). Obtaining the right return value is very important for risk managers and investors: both must be comfortable with the returns reported by the fund manager as it is this measure on which their returns are based. It is therefore important that one looks at the reporting standards.

Hedge funds are different to traditional funds as they chase *absolute* returns, rather than benchmark returns. There is no standard for evaluating hedge fund performance in South Africa (Bradley *et al.,* 2000:1). The lack of complexity in performance evaluation in the South African hedge fund industry is apparent in the disparity of views expressed regarding methodologies used for determining an appropriate risk/return relationship (Bradley *et al.,* 2000:1). The risk/return relationship is discussed in greater detail in Section 3.4.

The main driver for returns in hedge funds is a market anomaly or the capacity to exploit market situations or environments that traditional asset managers find difficult to access (Reech, 2004:7). The instruments invested in are determined largely by the strategy the hedge fund itself employs. Most hedge funds make use of derivatives to either hedge against a position or as an investment either to take advantage of the underlying or the volatility. Derivatives can be traded on an exchange such as SAFEX (South African Futures Exchange – a division of the JSE Securities exchange), LIFFE (London International Financial Futures and Options Exchange) and the (CBOT) Chicago Board of Trade, or it can be privately negotiated over the counter (OTC) (Goodspeed, 2004:63). On an exchange, instruments are marked-to-market on a daily basis, which assists with valuations and risk management. Exchanges apply margining arrangements and immediately margins cannot be met, the contract is terminated (Goodspeed, 2004:63).

Proper valuation is material both to hedge fund managers and investors and to the risk monitoring process (Rutter Asssociates, 2000:9). Hedge fund managers should develop procedures for capturing and verifying prices for the instruments they trade. They should rely on external price sources where data are available (Rutter Associates, 2000:9). This is important both for the valuation as well as the risk monitoring process, as many of the risk monitoring processes rely on these valuations. Risk monitoring and management are only as good as the valuations.

Valuations for risk management purposes could potentially be different from the NAV valuations, but these valuations may only be altered by senior management. For operational risk reasons, senior management should establish policies for determining returns when risk-monitoring valuations differ from NAV valuations. In cases where adjustment does take place, long positions should be adjusted downwards and short positions should be adjusted upwards (Rutter Associates, 2000:7). Examples of these adjustments are: unusual large position size, legal sale or transfer restrictions, illiquidity, control premiums, unusual hedging or transaction costs (Rutter Associates, 2000:10). Solutions that can be used for this are:

- bid prices could be used for long positions and ask prices for short positions, and therefore adjusting long positions upwards and short positions downwards,

- discounting the prices for a liquidity effect (liquidity will be discussed in more depth later in this dissertation) and
- for instruments subject to legal restrictions on sale where the market is illiquid or has become disorderly, it may be appropriate to make a downward adjustment from the fair value (Rutter Associates, 2000:7).

Hedge fund managers should establish procedures for verifying the accuracy of prices obtained from data vendors, dealers, or other sources (Rutter Associates, 2000:7).

Auditors and regulators want valuations to be based on "market quotes". Unfortunately, the illiquidity of many OTC instruments means market quotes do not always exist for these instruments (Reech, 2004:7). Securities such as shares and bonds that are traded each day can be marked-to-market at the close of every business day. Most OTC instruments can be marked-to-market (Goodspeed, 2004:63) only when they are traded and that may not always be regular. OTC instruments such as options need to have a value each day for the calculation of NAV's of the portfolio. In most cases these options do not trade on a daily basis, but their underlying does. There are several factors that determine the price of an option namely:

- the current asset or underlying price,
- the strike price,
- the time to expiration,
- the volatility of the underlying asset,
- the risk free interest rate,
- the dividends expected during the life of the option (Hull, 2000:168).

If the option is not traded on a daily basis, the theoretical value may be calculated if the *underlying* of the option is traded on a daily basis and can be marked-to-market every day. This is the market norm and will be the closest one can get to the real return of the portfolio with OTC options.

Options traded on an exchange are marked-to-market on a daily basis. Rutter Associates (2000:5) report that more than one quote from several, active, market dealers are

required to obtain a meaningful and accurate valuation of any option traded strategy. This is not always possible on a daily basis and theoretical prices may then be calculated.

It is usually the fund administrator that performs the valuation of the fund, but because some hedge funds use such complicated instruments, administrators sometimes find it difficult to cope with these instruments (Reech, 2004:7). Investors usually desire independent administrators to evaluate and perform risk analysis of the fund. Some institutions employ their own back office and perform these analyses on their own. To accomplish this end, an institution must have a good reputation in the business, be well trusted and must have reputable, independent auditors to check the process. Hedge fund managers, however, usually make use of prime brokers that provide software they may employ to trade as well as do the back office administration for them.

Hedge fund managers' internal controls and risk monitoring processes should be reviewed at least once a year. This should be done to ensure that reporting is complete and accurate and to find deviations from internal policies and procedures. Hedge fund managers valuation policies should be objective, fair, and consistent (Rutter Associates, 2000:11). External auditors should report any and all findings and any recommended actions in writing in the form of a management letter or other appropriate report.

The demanding exercise of pricing sometimes complex financial instruments was described in this section. The following section elaborates on several ratios which characterise both the risk and the performance of hedge funds.

3.4. Performance ratios

The South African hedge fund community has yet to converge on a standard for evaluating hedge fund performance (Fild, 2005:1 & Bradley *et al.,* 2000:3). In addition to the multitude of performance measures, the benchmark appraisals set by each fund also vary considerably (Fild, 2005:1 & Bradley *et al.,* 2000: 3). A small majority of funds simply do not benchmark their returns and instead, rely on a performance evaluation in absolute returns on capital (Old Mutual, 2005:1 & Bradley *et al.,*

2000:3). These funds cite a lack of comparable funds against which they can benchmark themselves, due to the uniqueness of the strategy they apply.

The lack of complexity in performance evaluation in the South African hedge fund industry is also apparent in the disparity of views expressed regarding methodologies used for determining an appropriate risk/return relationship. The South African hedge fund industry has varying views to incorporate a risk/return relationship (Fild, 2005:1 & Bradley *et al.*, 2000:4). According to many fund managers interviewed, the Sharpe ratio[16] is scarcely utilised, relative to its prevalence in the US and Europe. Fund managers prefer looking at risk and return intuitively, rather than to combine them into one number.

Only a small number of funds used techniques for determining a suitable link between risk and return in 2000, and approximately 29% of funds indicated that such methodologies are typically limited to Sortino ratios[17]. Another 14% of funds utilised BARRA[18] risk management systems.

In order to measure any risk/return relationship, whether it is the Sortino ratio, or the Sharpe ratio, it must first be clear how risk and returns are defined. In Section 3.1 *return* was defined, and its calculation elaborated upon. Risk, on the other hand, is often measured as the standard deviation of returns. This will be discussed in the next section.

3.4.1. Standard deviation

The standard deviation is defined as:

> "a statistical measure of the degree to which an individual value in a probability distribution tends to vary from the mean of the distribution. It is widely applied in modern portfolio theory, for example where the past performance of securities is used to determine the range of possible future performances and probability is attached to each performance. The standard deviation of performance can then be calculated for each security and

---

[16] Excess returns from the risk free rate relative to the standard deviation of those returns.
[17] Excess return from the target relative to a measure of downside risk, which help determine the volatility displayed in monthly returns.
[18] A third party, proprietary risk management system commonly used by asset managers.

for the portfolio as a whole. The greater the degree of dispersion the greater the risk." (Dowd, 1998:20).

It is very common to refer to the "standard deviation of returns" as "risk" in modern finance.

The standard deviation is based on the deviation from the mean. The standard deviation is the positive square root of the arithmetic mean of the squared deviations from the mean (Mason *et al.,* 1999: 349). The standard deviation of a return series is often referred to as the *volatility* of a return series. The return series can be observed at fixed intervals of time (e.g. daily, weekly or monthly). The return may be calculated as given in Equation 3-1 (known as the arithmetic rate of return), but this method has the drawback of allowing the possibility of returns of less than -100%. Returns may also be continuously compounded (known as the geometric rate of return, which has the benefit of making calculations simpler: the n-geometric mean is simply the sum of n successive one-month geometric means) as follows,

$$r_t = \ln\left(\frac{S_t}{S_{t-1}}\right), \qquad \textbf{3-3}$$

(Hull, 2000:424),

where S_t is the price of an asset at period t and

S_{t-1} is the price at the previous period.

Standard deviation is then given by:

$$\sigma = \sqrt{\frac{1}{T-1}\sum_{t=1}^{T}(r_t - \bar{r})^2} \qquad \textbf{3-4}$$

(Hull, 2000:424),

where

n is the number of observations,

r_t is the return at end of the t th interval (t=0,1,... T) and

the $\bar{r}$ indicates the average of all prices in the interval (Hull, 2000:424).

Choosing the time intervals is not easy, nor is choosing the correct n. Usually, more data are more accurate, but if one uses too much data (i.e. the data samples too far into the past) these data have no affect on the market at the present time (Hull, 2000:242). Large amounts of return data may also conceal large outliers (because of averaging) that could reveal important information about hedge fund returns.

Standard deviation is a traditional measure often used by investment professionals for measuring risk. It measures an investment's variability of returns; i.e. its volatility in relation to the average return. Specifically, it expresses the range within which returns are expected to fall roughly two-thirds of the time, assuming a normal distribution of returns. While standard deviation has the cachet of science, it is a rather narrow measure and may not provide as much information by itself as a comprehensive visual scan of returns by a knowledgeable investor who can draw good, intuitive conclusions. Standard deviation is simply a measure of volatility and is of limited use unless, in interpreting it, one pairs it with returns as in the Sharpe ratio (see next subsection) or the Van ratio (VAN Hedge Fund Advisors International, 2000:12).

3.4.2. Sharpe ratio

The Sharpe ratio a risk-adjusted financial measure developed by Nobel Laureate William Sharpe. It uses a fund's standard deviation and excess return to determine the reward per unit of risk (Fischer Investments, 2001c:1). The higher a fund's Sharpe ratio, the better the fund's "risk-adjusted" performance (Weissterin, 1999:1).

The Sharpe ratio then measures the ratio of the excess returns over the sample period, divided by the standard deviation of those returns.

Mathematically, this is given by:

$$\text{Sharpe ratio} = \frac{\left(r^P - r^B\right)}{\sigma}, \qquad \text{3-5}$$

where r^P is the return of the portfolio,

r^B is the return of the benchmark or in many cases the money market (risk free rate) and

σ is the standard deviation of the portfolio returns (Bodie *et al.*, 1999:754).

Leverage was originally thought not to affect the Sharpe ratio to a great extent. It was believed that, as a fund became more leveraged, returns would increase but so would the standard deviation due to bigger bets that the fund is exposed to, relative to its size. Fulkes (1998:1) showed that this is not the case, as illustrated in Table 3.1. The two quantities do not increase at the same rate, which explains the decreasing Sharpe ratio.

Table 3-1 Table 3.1: Results showing the effect of leverage on the Sharpe ratio.

Leverage	Std Dev	Return	Sharpe
1	46%	32%	0.58
2	73%	42%	0.50
3	126%	63%	0.46
4	182%	82%	0.42
5	242%	99%	0.39
6	286%	107%	0.36
7	358%	123%	0.33
8	437%	138%	0.30
9	523%	152%	0.28
10	592%	158%	0.26

(Fulkes, 1998).

If, without leverage, an investment loses 10% in one month, it would require 11% return to get back to the start point [$90\% \times 111\% = 100\%$]. With a leverage of 2 to 1, this investment would lose 20% in that same month. It would then require 25% to return to par [$80\% \times 125\% = 100\%$]. Achieving a 20% gain would only place the fund at 96% of the original value [$80\% \times 120\% = 96\%$].

With leverage of 5 to 1, this investment would lose 50% in that month. Then it would require 100% return to return to par again [$50\% \times 200\% = 100\%$]. Achieving a 50% gain would only get up back to 75% of the original value [$50\% \times 150\% = 75\%$].

With leverage of 10 to 1, this investment would lose 100% in that month and the fund would be bankrupt. So with higher and higher leverage, the standard deviation continues to increase and the variations in monthly returns bias the returns lower than we would otherwise expect. This lowers the risk-adjusted return and the Sharpe ratio. Thus, the Sharpe ratio is roughly independent of leverage only so long as the standard

deviation does not get too high (Fulkes, 1998:2).

In conclusion, the Sharpe ratio measures the return relative to risk, and a higher Sharpe ratio is more preferable. The example states that as leverage increase the lower the Sharpe ratio gets, but this is not always true. Some hedge funds produce a higher return without increasing the leverage. This also depends on the strategy involved and the example only takes into account long-only portfolios. When combining risk and return, the scaling of these quantities causes some problems to arise (see later in this chapter). The Sharpe ratio is a good measure to compare funds with, but alongside that the Sortino ratio needs to be considered.

3.4.3. Sortino ratio

> "The Sortino ratio is a variation of the Sharpe ratio which differentiates harmful volatility from volatility in general using a value for downside deviation. The Sortino ratio is the excess return over risk-free rate over the downside semi-variance, so it measures the return to "bad" volatility. This ratio allows investors to assess risk in a better manner than simply looking at excess returns to total volatility, since such a measure does not consider how often the price of the security rises as opposed to how often it falls." (Investorwords, 1997:1).

As described in Section 3.4.1., one of the most commonly used measurements of risk is the standard deviation. In Equation 3-4 no distinction is made between upside and downside deviation. For this reason, an investment with monthly returns of -5% and +5% will have the same standard deviation as another investment with 0% returns one month and +10% the next (Investorwords, 1997:1).

The Sharpe ratio is therefore using a non directionally-biased measurement of volatility to adjust for risk. This concept has been criticized, as it may actually punish a fund for a month of exceptionally high performance. For many individuals, this type of deviation is not only unacceptable, but also undesirable. It is for this reason that the Sortino ratio was developed.

In short, the Sortino ratio only measures the downside volatility, and is given as:

$$\text{Sortino Ratio} = \frac{\left(r^P - r^B\right)}{\sigma_d}, \qquad \textbf{3-6}$$

(Bodie *et al.*, 1999:758)

where r^P is the return of the portfolio,

r^B is the return of the benchmark or risk free rate and

σ_d is the downside volatility of the portfolio returns.

Instead of using standard deviation in the denominator, the Sortino ratio uses only the volatility of the negative portfolio returns. This gives a measurement of return deviation below a minimal acceptable rate, as determined by the fund manager. By utilizing this value, the Sortino ratio is only penalizing for "harmful" volatility. It is a measurement of return per unit of risk on the downside (Investorwords, 1997:1).

Although there are arguments in favour of both ratios, the Sharpe ratio has been used more in the hedge fund arena. In some cases, this may reflect a certain comfort level associated with its use of standard deviation, which is a more traditional measurement of volatility. Funds that cite their Sortino ratio have traditionally been those with the least tolerance for risk. In these cases, the Sortino ratio may be presented as a compliment to an investment dissertation that stresses the containment of losses to a minimum.

Although both the ratios are measurements of return-to-risk, understanding the distinctions of each may provide insight into their unique drawbacks.

3.4.4. Information ratio

The Information or Appraisal ratio is defined as the quotient of the active return and the active risk where active refers to the fact that this is a measure relative to a given benchmark (Fischer Investments, 2001a:1). It is similar in form to the Sharpe ratio, but for the fact that both risk and return are measured relative to a benchmark.

Thus

$$IR = \frac{\left[\prod_{t=1}^{T}\left(1+\left(r^P - r^B\right)_t\right)\right]-1}{\left(\frac{1}{T-1}\sum_{t=1}^{T}\left(\left(r^P - r^B\right)_t - \overline{\left(r^P - r^B\right)}\right)^2\right)\cdot\sqrt{T}} \qquad \text{3-7}$$

where r^P is the historical portfolio return, r^B the historical benchmark return and the overbar indicates the mean of the relevant quantities (Bodie *et al.*, 1999:787).

The Information ratio is not a very popular ratio amongst hedge funds, as there are different opinions regarding an appropriate benchmark to be used (discussed in Chapter 2).

3.4.5. Drawdown

Drawdown measures the change in the value of a portfolio from a defined peak to a subsequent trough (Reech, 2004:4). It therefore measures the percentage change in a manager's NAV from a high water mark[19] to the next low water mark[20] (Futures *et al.*, 2003:14).

The maximum drawdown measures the maximum change in value of a portfolio from a defined peak to a subsequent trough. Despite the peak to trough drawdown being a widely quoted measure of risk for hedge funds and commodity trading advisors, investors do not appear to have a widely accepted way of forming expectations about how much managers might lose.

The three most important determinants of drawdowns in hedge funds are length of track record, mean returns and standard deviation of returns (Futures *et al.*, 2003:14). Futures *et al.*, (2003:14) used a Monte Carlo simulation in which they controlled the distributions of returns for the length of the track record. They observed a few factors such as length of track record, mean return, standard deviation of return, skewness and kurtosis. Of these the only three that have any empirical importance seem to be length of track record, mean return and standard deviation of return (Futures *et al.*, 2003:14).

Higher mean returns also leads to smaller expected drawdowns. Volatility also has a huge influence on drawdowns: the higher the volatility the larger the expected draw-

---

[19] A NAV qualifies as a high water mark if it is higher than any previous NAV, and is followed by a loss, or if one is at the end of a data series.
[20] A NAV qualifies as a low water mark if the lowest NAV is between two high water marks or if one is at the end of a data series.

downs. The likelihood of any given drawdown is independent of how long the manager has been in business and the likelihood of experiencing any drawdown that is larger than anything experienced so far increases with every passing day (Futures *et al.*, 2003:14).

The biggest factor that contributes to drawdowns is the return volatility. Volatility is twice as important to drawdowns than mean returns, which is then three times as important than skewness and kurtosis (Futures *et al.*, 2003:14). Doubling a manager's mean return while holding the return volatility constant will, therefore, reduce the expected drawdown per unit of volatility by less than half. In turn, a doubling of volatility while holding mean return constant will more than double the expected maximum drawdown per unit of volatility. The doubling of both mean return and volatility, which will leave the Sharpe ratio unchanged, would exactly double the expected maximum drawdowns (Futures *et al.*, 2003:16). This suggests two things: managers with the same volatility of returns, but different mean returns, will have different expected drawdowns, and that managers with the same Sharpe ratio, but different volatilities, will have different drawdowns.

3.4.6. Scaling problems with risk and return

Hedge fund managers and risk practitioners have always required accurate and reliable risk and return measures, but in today's highly competitive financial world those requirements have become even more onerous. The few equations used to quantify these components have already been described in this chapter, and are not complex measures. Despite this relative simplicity, risk and return measures are often misunderstood and incorrectly implemented, especially where scaling in time is involved and in situations where combinations of risk and return are required such as the Sharpe and Appraisal (or Information) ratios. A better understanding of the *fundamental* nature of both risk and return measures helps clarify these misunderstandings and paves the way toward improved accuracy.

In this section the assumptions behind the measures will be explored. Standard, single-period definitions will then be extended to embrace longer-term ones. This approach exposes the little-known intricacies of scaling in time to which these measures

are subject. Having established these subtleties, various quantities that involve either or both measures are explored to ascertain the effects of the differential scaling. The calculation of returns has been described earlier in the chapter. In order to simulate possible investment returns, the random walk with drift model will be used.

The fundamental archetype of asset price dynamics is the random walk with drift model (JP Morgan, 1996:32). Portfolio prices, P_t, are assumed to follow this process, namely: $P_t = \theta + P_{t-1} + \sigma\varepsilon_t$ where θ is the growth in period t and the disturbance term, ε, is identically and independently distributed (JP Morgan, 1996:32). The white noise process, ε_t, has an expected value $E[\varepsilon_t] = 0$, constant variance ($\sigma^2 \neq \sigma^2(t)$) and is uncorrelated with any past values of ε_t.

Most hedge fund managers only supply investors with monthly return data for use in the estimation of both portfolio risk and return. Portfolio pricing on a weekly and daily basis is possible, of course, but these data are not generally available for the investors. *Monthly* prices and returns are, however, reported, by the hedge fund manager and form the basis of the results presented here. (The analysis discussed in this dissertation was also performed on weekly and daily price data and identical results were found.)

Arithmetic monthly returns are determined using a variation of Equation 3-1, namely:

$$r_t = \frac{P_t - P_{t-1}}{P_{t-1}} \qquad \textbf{3-8}$$

where P_{t-1} is the value of the portfolio in the $(t-1)^{\text{th}}$ month and P_t the value in the t^{th} month.

The interpretation of the monthly risk measure is straightforward. Since σ represents, by definition, one standard deviation from the arithmetic mean of the return observations, $\bar{r}_a$, approximately 68% of all returns measured over the period concerned will fall between

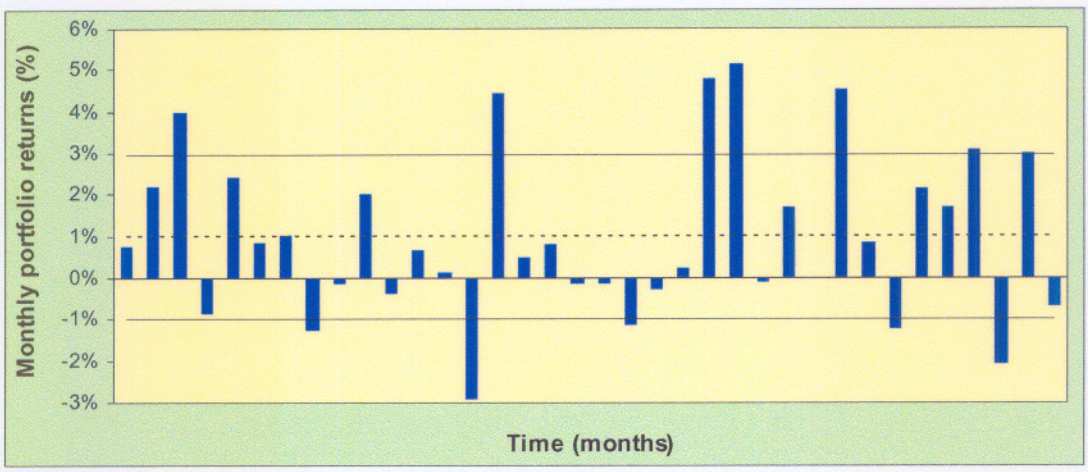
$$\bar{r}_a \pm \sigma. \qquad \textbf{3-9}$$

A database of five South African Hedge fund managers' monthly returns – measured

over three years – was used in this study. In addition, the results were tested with long only managers and no differences were found.

Figure 3.1. shows a sequence of 36 months of returns for one particular asset manager for which $\bar{r}_a = 1\%$ and $\sigma = 2\%$. By definition, approximately 68% of the returns fall within $r_t \in [\bar{r}_a \pm \sigma]$ or $r_t \in [-1\%, 3\%]$. The volatility or risk band (i.e. ±1 standard deviation) measured over this period is shown as solid lines on either side of the average arithmetic return – shown as a dotted line – measured over 36 months. Approximately 68% of all returns in this period lie within the solid lines.

Figure 3-1 Three years of monthly returns with $\bar{r}_a = 1\%$ and $\sigma = 2\%$



3.4.6.1. Scaling up

The values discussed so far are *monthly* figures, but reporting standards often demand *annualised* (or greater time period) values of risk and return quantities. The "scaling-up" of these measures is a simple operation, but the interpretation requires a fundamental understanding of the way in which financial quantities scale.

Assuming the portfolio structure is unchanged, the cumulative portfolio return, r_T, over any period of T months is calculated using the relevant monthly portfolio returns, r_t:

$$r_T = \left[\prod_{t=1}^{T}(1+r_t)\right]-1 \qquad \textbf{3-10}$$

The geometric average monthly return, $\bar{r}$, is measured using

$$r_T = (1+\bar{r})^T - 1 \qquad \textbf{3-11}$$

or

$$\bar{r} = \sqrt[T]{1+r_T} - 1 \qquad \textbf{3-12}$$

Note that this analysis proceeds from simple returns as calculated in Equation 3-8. Using continuously compounded returns is also a commonly employed method used to measure returns. The conclusions reached in this study, however, apply equally well to simple *and* continuously compounded returns[21].

It can be shown that the one-period forecast error is $e_1 = r_{t+1} - E[r_{t+1}] = (\bar{r}_a + r_t + \varepsilon_{t+1}) - (\bar{r}_a + r_t) = \varepsilon_{t+1}$ where r_{t+1} is the $(t+1)^{\text{th}}$ period forecast error and $E[r_{t+1}]$ is the expected value of the $(t+1)^{\text{th}}$ period return, and that $\text{var}(\varepsilon_1) = \text{var}(\varepsilon_{t+1}) = \sigma^2$ (Gujarati, 1995:52). The T^{th} period variance, therefore, is $\text{var}(e_T) = \sigma^2 \cdot T$ and the standard deviation after T months is given by $\sigma \cdot \sqrt{T}$.

Extending the definition of Equation 3-9 and combining Equation 3-10 and 3-11 leads to the fact that approximately 68% of all *cumulative* returns measured over a period of T months will lie between $\left((1+\bar{r})^T - 1\right) \pm \sigma \cdot \sqrt{T}$. These results are summarised below in Table 3-2 out to two years.

---

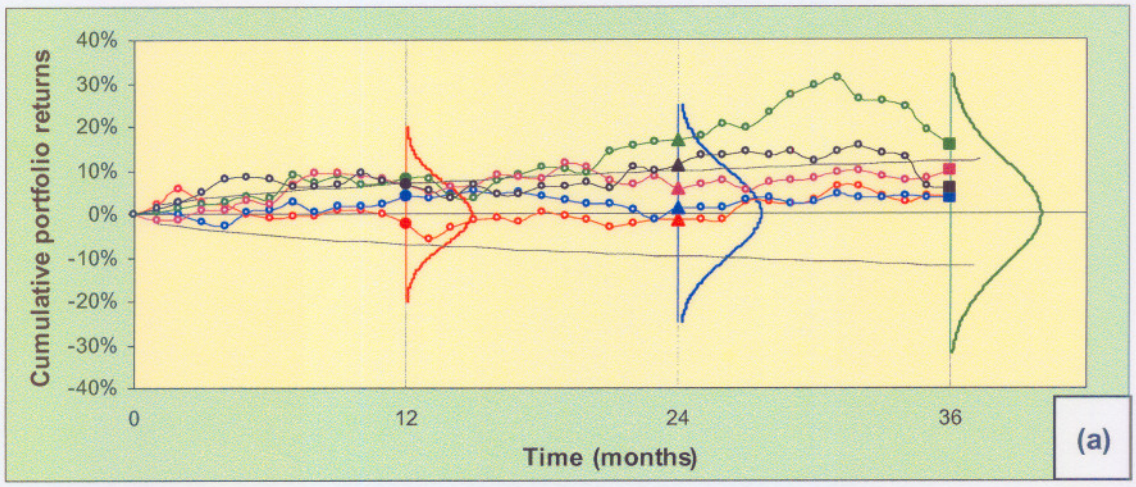
[21] Consider T months of continuously compounded monthly returns, r_t. By definition, the total return over T months is $r_T = \sum_{t=1}^{T} r_t$. If $\bar{r}$ is the average monthly return, Equation 3-12. becomes (for this case) $r_T = T \cdot \bar{r}$.

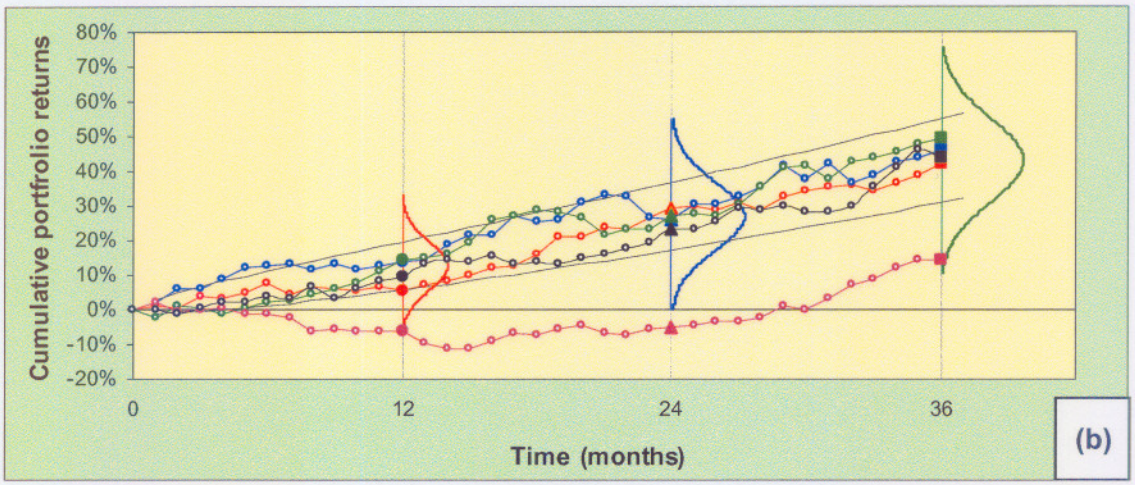
Table 3-2 Return and risk measured over various periods.

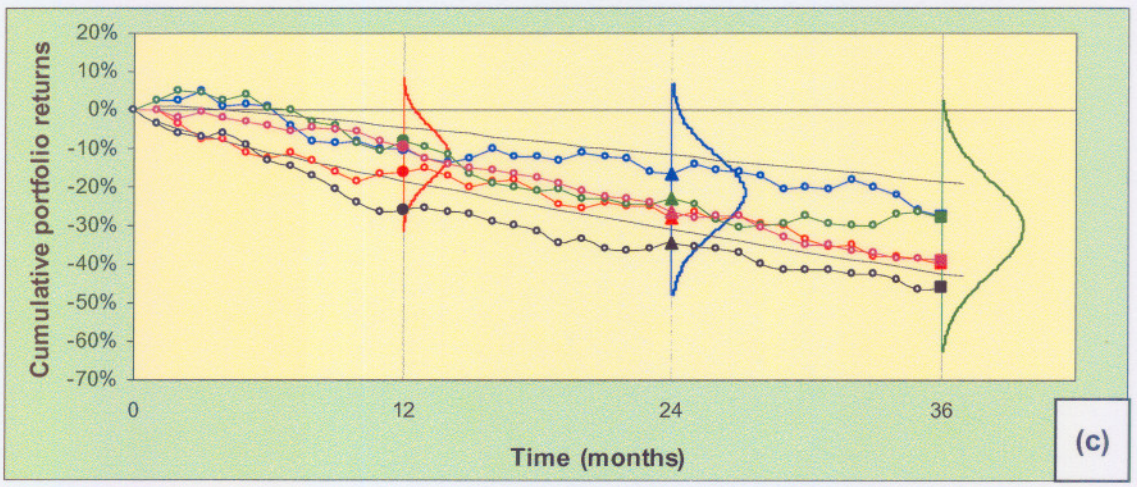
	Monthly	After T periods
Actual return	r_t	$\left[\prod_{t=1}^{T}(1+r_t)\right]-1$
Average return	$\bar{r}_a$	$(1+\bar{r})^T-1$
Risk	$\pm\sigma$	$\pm\sigma\sqrt{T}$

Figure 3.2 shows sequences of cumulative returns measured over a three-year period for five selected South African asset managers. The monthly standard deviation was measured as 2% in all cases. The volatility or risk band (i.e. ±1 standard deviation) is shown (solid lines) evolving over the 36 months according to Equation 3-4. Closed circles, triangles and squares represent the annual, 2-year and 3-year cumulative returns, respectively. Approximately 68% of relevant returns were found to lie within ± one standard deviation, 16% in the region $r \geq \left[(1+\bar{r})^T-1\right]+\sigma\sqrt{T}$ and 16% in the region $r \geq \left[(1+\bar{r})^T-1\right]-\sigma\sqrt{T}$, as predicted by theory.

Figure 3-2 One, two and three years of cumulative monthly returns for five different asset managers with (a) $\bar{r} = 0$, (b) $\bar{r} = +1\%$ and (c) $\bar{r} = -1\%$.







3.4.6.2. Scaling down

It is common practice, however, *in an effort to obtain better estimates of long-run annual returns*, to use 2-year, 3-year or even longer periods of cumulative returns and "annualise" or "scale down". The technique employed is again straightforward (in fact, it involves determining the geometric average of the data set), but often incorrectly applied. Consider the case in which 24 months of cumulative return data are used to obtain an annual cumulative return.

Using Equation 3-11 above

$$\bar{r}_{2y} = \left(1 + \bar{r}_{1y}\right)^2 - 1 \qquad \textbf{3-13}$$

that is, it is assumed that the geometric average cumulative 2-year return may be calculated using two, equal annual returns, $\bar{r}_{1y}$. Rearranging Equation 3-10 gives

$$\begin{aligned}
\bar{r}_{1y} &= \left(1 + \bar{r}_{2y}\right)^{\frac{1}{2}} - 1 \\
&\cong 1 + \frac{\frac{1}{2}\bar{r}_{2y}}{1!} + \frac{\left(\frac{1}{2}\right)\left(-\frac{1}{2}\right)\cdot\bar{r}_{2y}^2}{2!} + \frac{\left(\frac{1}{2}\right)\left(-\frac{1}{2}\right)\left(-\frac{3}{2}\right)\cdot\bar{r}_{2y}^3}{3!} + \cdots - 1 \text{ (by Taylor expansion)} \\
\bar{r}_{1y} &\cong \tfrac{1}{2}\bar{r}_{2y} - \tfrac{1}{8}\bar{r}_{2y}^2 + \tfrac{1}{16}\bar{r}_{2y}^3 + \cdots
\end{aligned}$$

Given that the cumulative rates of return for "standard" portfolios, even after 2 years, is generally "small", it is not unreasonable to ignore terms $\geq \bar{r}^2$ and thus

$$\bar{r}_{1y} \cong \tfrac{1}{2}\bar{r}_{2y}. \qquad \textbf{3-14}^{22}$$

The geometric average (or annualised) rate of return is approximately half the 2-year rate. Equation 3-14 however, conceals important information and ignores other rele-

---

[22] Equation 3-14 becomes $\bar{r}_{2y} = 2\cdot\bar{r}_{1y}$, i.e. the average 2-year rate is exactly double the average 1-year rate. This is a key point: continuously compounded average returns scale *exactly* linearly, not *approximately* linearly using Taylor expansion as in the case for simple returns. In the analysis that follows in the dissertation, it was show that $\bar{r}_{1y} \cong \frac{1}{2}\bar{r}_{2y} - \frac{1}{8}\bar{r}_{2y}^2$ using the Taylor series on simple returns, whilst using continuously compounded returns we obtain $\bar{r}_{1y} = \frac{1}{2}\bar{r}_{2y}$. The returns in Figure 3.4 scale only approximately with T, whilst the continuously compounded ones scale exactly with T. The majority of fund managers and consultants use simple returns, however, hence the analysis in this section.

vant features of this exposition. Recall from Table 3.2 that the 2-year cumulative returns fall within the range

$$r_{2y} \in \left[\bar{r}_{2y} \pm \sigma\sqrt{24}\right] \text{ (with probability ~68\%).}$$

Dividing through by 2 gives

$$\frac{1}{2}\cdot r_{2y} \in \left[\frac{1}{2}\cdot \bar{r}_{2y} \pm \frac{1}{2}\cdot \sigma\sqrt{24}\right] \textbf{ with probability ~68\%.} \qquad \textbf{3-15}$$

and using $\bar{r}_{1y} \cong \frac{1}{2}\bar{r}_{2y}$. 3-14 gives[23]

$$r_{1y} \in \left[\bar{r}_{1y} \pm \frac{\sqrt{2}}{2}\cdot \sigma\sqrt{12}\right] \textbf{ with probability ~68\%.} \qquad \textbf{3-16}$$

However, recall from Table 3.2 that, in fact, for 1-year cumulative returns

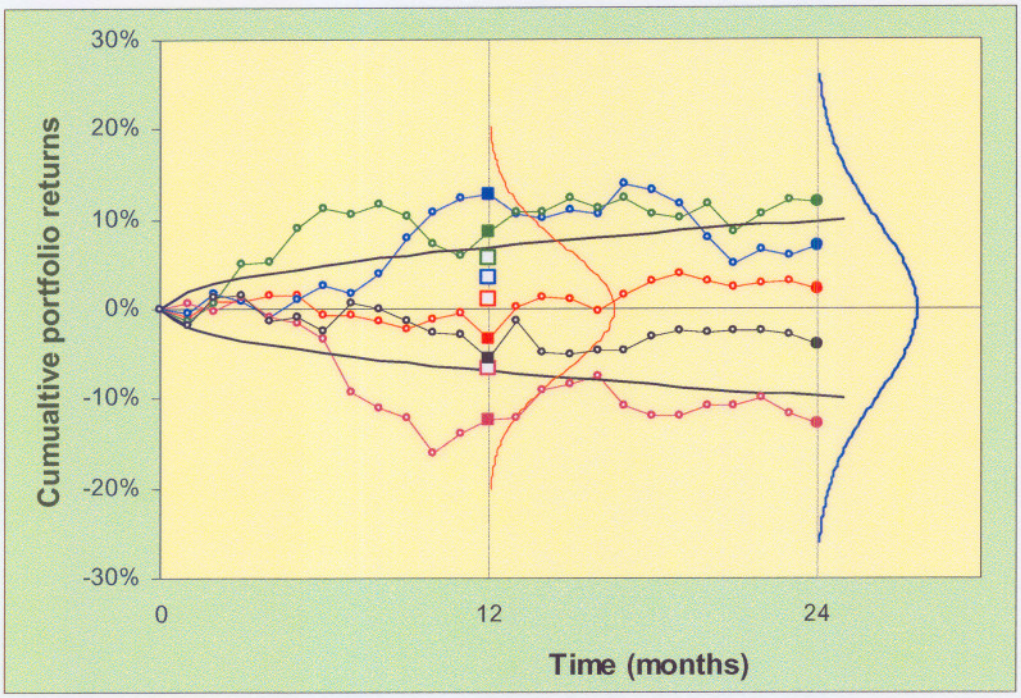
$$r_{1y} \in \left[\bar{r}_{1y} \pm \sigma\sqrt{12}\right].$$

Thus, geometric averaging fails to account for the change in the risk profile because of the differential scaling of risk and return. On average, therefore, the range $(\pm 1\times\sigma)$ of 1-year returns estimated from Equation 3-14 above will be a factor of $\sqrt{2}/2\,(\approx 71\%)$ times their true range as shown in Figure 3.3. The risk band is again shown evolving in time over the 24 months. Closed squares and circles represent the annual and 2-year cumulative returns, respectively. Open squares represent annualised (scaled-back) returns calculated from the 2-year values (closed squares) using Equation 3-14. Although only five data sets are shown here, of all the sequences studied it was found that, on average, the width (range) of the open squares (i.e. r_{1y} [calculated]) was a factor of $\frac{\sqrt{2}}{2} \cong 0.71$ times the range of the closed squares (i.e. r_{1y} [measured]) as predicted by theory.

---

[23] It is important to note that the claim here is that (from Equation 3-11 $\bar{r}_{1y} \cong \frac{1}{2}\bar{r}_{2y}$ and *not* that $r_{1y} \cong \frac{1}{2}r_{2y}$ as might seem to be implied from Equations 3-12 and 3-13. Note that it is the *range of possible returns* that fall within ± one standard deviation from the mean to which we refer in these equations, *not* that $r_{1y} \cong \frac{1}{2}r_{2y}$.

Figure 3-3 One and two years of cumulative monthly returns for 5 different South African asset managers with $\bar{r} = 0$ and $\sigma = 2\%$.



Using 36 months of cumulative return data works in a similar way. Proceeding via the same logic as before, it can be shown that $\bar{r}_{1y} \cong \frac{1}{3}\bar{r}_{3y}$ and thus

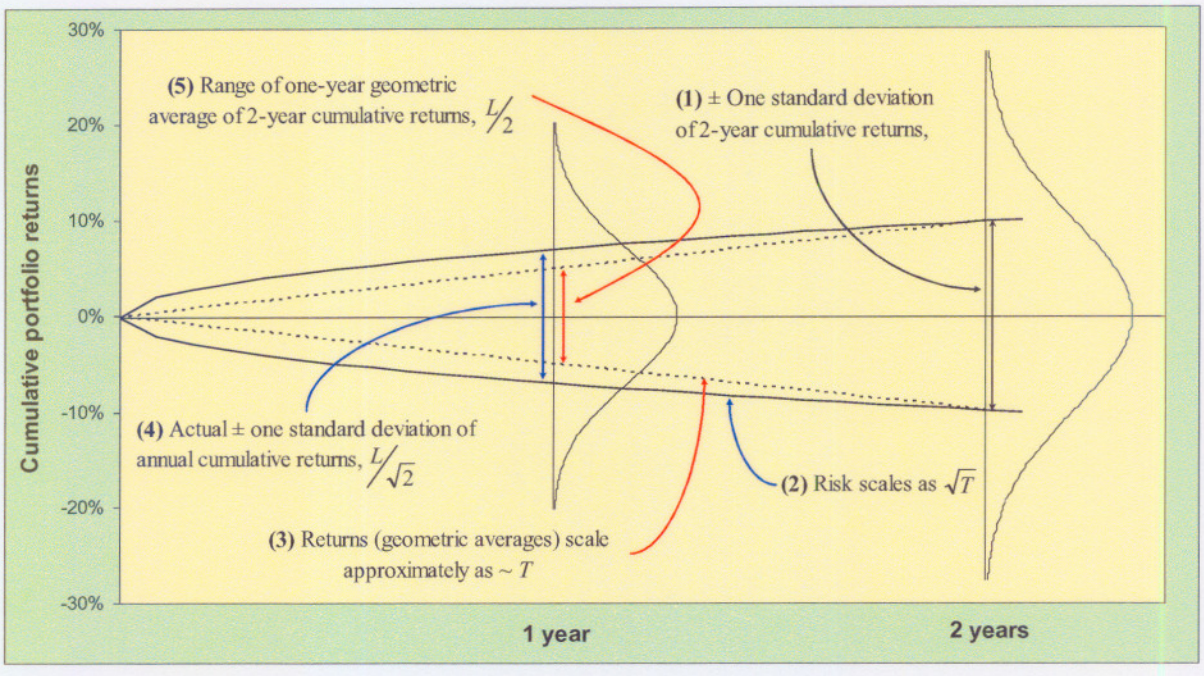
$$r_{1y} \in \left[\bar{r}_{1y} \pm \frac{\sqrt{3}}{3} \cdot \sigma\sqrt{12}\right] \qquad \textbf{3-17}$$

yet, according to Table 3.1, for one-year cumulative returns

$$r_{1y} \in \left[\bar{r}_{1y} \pm \sigma\sqrt{12}\right]. \qquad \textbf{3-18}$$

Hence, if three years of monthly data are used then, on average, the range $(\pm 1 \times \sigma)$ of 1-year returns estimated from Equation 3-14 will be a factor of $\sqrt{3}/3$ $(\approx 58\%)$ times their true range, and so on. Figure 3.4 presents a graphical summary of these results.

Figure 3-4 Graphical explanation of theory formulated in the text.



3.4.6.3. Scaling problems affecting ratio's

Several ratios (such as the Sharpe, and Information ratios explained earlier in this chapter) will be affected if correct scaling is not applied. When considering the Sharpe ratio, the situation arises where a combination of risk and return are manifest in the same equation, with each factor scaling differently in time. As long as the correct measures are used (i.e. 1 year of cumulative returns with 1-year volatilities, 2 years of cumulative returns with 2-year volatilities, and so on), the values obtained for this ratio will be valid. Scaling backwards using more than one years' worth of return data to obtain annual values will consistently *under*estimate the Sharpe ratio.

Again the same with the information ratio, where a combination of risk and return occurs in the same equation, and again, caution must be exercised when scaling these quantities. Failure to account for differential scaling produces, on average, *smaller* Appraisal ratios than those actually attained.

The equations that are employed to determine risk and return are neither complicated nor difficult to implement and are commonplace in the hedge fund arena. Despite this simplicity, these measures are sometimes misunderstood at the basic level and thus incorrectly implemented when scaling in time is required. A good understanding of

the *fundamental* nature of both risk and return measures helps clarify these misunderstandings and prevents this confusion.

3.4.7. Funding liquidity risk

Funding liquidity risk is also a very important measure to consider when investing in a hedge fund. This measures the hedge fund manager's ability to continue trading in times of stress (Rutter Associates, 2000:16). Note that liquidity in this context refers specifically to liquidity from a *funding* point of view and not from a market risk measurement point of view. This latter viewpoint is discussed in Section 4.5.

Funding liquidity analysis should take into account the investments strategies employed, the terms governing the rights of investors to redeem their interests and the liquidity of assets. Adequate funding liquidity gives a hedge fund manager the ability to continue a trading strategy without being forced to liquidate assets when losses arise (Rutter Associates, 2000:16).

Hedge fund managers should be concerned about a convergence of risks, such as market or credit risk events affecting illiquid positions that are leveraged. Such a confluence of events could require the hedge fund to liquidate positions into a market that cascades in price because of a high volume of liquidation orders. Such a situation could be decomposed into three stages (Rutter Associates, 2000:12):

- a loss that acts as the triggering event,
- a need to liquidate positions to raise cash, because of this loss. The liquidation may be required either because the fund must post margin with its counterparties or because of redemptions by investors due to the loss,
- a further drop in the fund's NAV as the market reacts to actions by the fund. Attempts by the fund to sell in too great a quantity or too quickly for the market liquidity to bear can cause a further drop in prices, precipitating a further decline in the fund's NAV, and leading in turn to yet a further need to liquidate to satisfy margin calls or redemptions. This downward spiral can be exacerbated if other market participants have information about the fund's positions.

The point of no return comes when the effect of liquidation has a greater impact on the value of the remaining fund position than the amount of cash raised from the liquidation. If this happens, the fund is caught in an accelerating, downward spiral and eventually it will not be able to satisfy the demands of its creditors or investors. Once the losses move beyond a critical point, it becomes a self-sustaining crisis that feeds off of the need for liquidity, a need imposed by the demands of the fund's creditors and investors.

The hedge fund manager should know where a fund's cash is deployed and the reason for deploying it. Hedge fund managers should centralise cash management and should evaluate the costs and benefits of leaving excess cash in trading accounts (e.g. margin accounts). Hedge fund managers should therefore employ appropriate liquidity measures in order to gauge on an ongoing basis whether a fund is maintaining adequate liquidity. The following ratios or measures should help in this regard.

- Cash[24]/Equity,
- VAR[25]/(Cash + Borrowing Capacity)[26],
- Worst historical drawdown/(Cash + Borrowing capacity).

Hedge fund managers should assess their cash and borrowing capacity under the worst historical drawdown and stressed[27] market conditions (by assuming worst case scenarios on securities used for collateral in margin borrowings (Rutter Associates, 2000:16). Taking into account investor redemptions and contractual arrangements that

---

[24] Cash refers to cash plus cash equivalents (short term, high quality investments)

[25] Value at Risk (VAR) An integrated measure of the market risk of a portfolio of assets and/or "liabilities". At the most general level, VAR is a measure of the potential change in value of a specified portfolio over a specified time interval or holding period, resulting from potential changes in market factors (e.g., prices and volatilities). The VAR measure is based on the distribution of potential changes in the value of the portfolio and is expressed in terms of a confidence level. A Hedge Fund Manager's risk monitoring function should use VAR to estimate the maximum expected amount a Hedge Fund could lose over a specified time horizon at a specified probability level. For instance, the risk monitoring function could calculate the maximum expected loss for a one-day period at a 95% probability level - i.e., the level of loss that should be exceeded on only five trading days out of 100. (Sound practice for hedge fund managers, appendix 3, 12)

26 Cash + Borrowing Capacity = Cash plus access to borrowings e.g. under margin rules or credit lines.

27 Worst Historical Drawdown. This indicator provides a measure of risk and of the amount of liquidity the Fund has required in the past. This measure is, however, a backward-looking measure of risk and may not be indicative of the fund's current exposure.

affect a Fund's liquidity (notice periods for reduction of credit lines by counterparties, (Rutter Associates, 2000:16)).

Hedge fund managers should periodically forecast their liquidity requirements and potential changes in liquidity measures (Rutter Associates, 2000:18).

Hedge fund managers should perform scenario tests to determine the impact of potential changes in market conditions on a fund's liquidity. Among these scenario tests, hedge fund managers should consider including the potential response to a creditor experiencing a liquidity problem during times of market stress (e.g. reluctance to release collateral, (Rutter Associates, 2000:17)).

Hedge fund managers should also take into account redemption periods "windows" or other rights of investors to redeem their interests, (Rutter Associates, 2000:17). Hedge fund managers should also take into account the relationship between a fund's performance and redemptions and between a funds performance and the availability of credit lines (Rutter Associates, 2000:19).

Liquidity is a very important measure for hedge funds, but represents only one aspect of the ratios that are constructed for hedge funds and finance. Looking at the risk and return of a fund there are a couple more ratios that are important in the hedge fund community. The average hedge fund has outperformed both broad market indicators and U.S. mutual funds (VAN Hedge Fund Advisors International, 2000:14). VAN Hedge employ three main measures of risk. This dissertation will define them here according to VAN Hedge and describe them later in more detail. These three measures are:

- the standard deviation: measures the volatility of returns around the mean, a high standard deviation indicates a volatile investment,

- the Sharpe ratio: a reward-risk ratio. The higher the Sharpe ratio, the more reward an investment provides for the risk incurred,

- the Van ratio: measures the probability of an annual loss (of any 10 magnitude). A 20% Van ratio indicates a one-in-five chance of a loss in any year. The Van

ratio is unique to the Van Hedge Fund Advisors International.

Investment "risk" tends to be viewed differently by academics and by investors. To the academic, "risk" within modern portfolio theory is defined as standard deviation or volatility. To the average investor, "risk" usually is the probability of a loss (VAN Hedge Fund Advisors International, 2000:14). Indeed, Webster's Dictionary (Downes, 2003:304) defines "risk" as "possibility of a loss..." ,"the chance of a loss. . .", "the degree of probability of such a loss". Risk measures the possibility of losing or not gaining value. Risk is differentiated from uncertainty, which is not measurable (Downes, 2003:304). Standard deviation does not measure the probability of a loss unless one also takes into account the mean return of that investment (VAN Hedge Fund Advisors International, 2000:16). For example, Investment A with a very high standard deviation, may be less likely to incur a loss than Investment B which has a very low standard deviation[28]. Investment A has a standard deviation of 20% and a mean return of 35%, whereas investment B has a standard deviation of 5% but a mean return of 3% (VAN Hedge Fund Advisors International, 2000:16).

Risk and performance ratios – used to rank hedge funds – were presented in this section. The overarching secrecy which shrouds the hedge fund industry, and the reasons behind this, are discussed in the next section.

3.5. Disclosures and transparency

Investors should receive periodic performance and other information about their hedge fund investments. Hedge fund managers should also consider whether investors should receive interim updates on other matters in response to significant events. Hedge fund managers should negotiate with counterparties to determine the extent of financial and risk information that should be provided to them based on the nature of their relationship in order to increase the stability of financing and trading relationships. They should also work with regulators and counterparties to develop a consensus approach to public disclosure. Agreements and other safeguards should be estab-

[28] The standard deviation, if added and subtracted to the mean, provides the range within which returns will fall two thirds of the time, in a normal distribution. The standard deviation is defined as the arithmetic mean of the squared deviations of the observations from their mean. See Section 3.4.1.

lished in order to protect against the unauthorized use of proprietary information furnished to outside parties (Rutter Associates, 2000:21).

When reporting to a fund's governing body and investors, the investment objectives and approach plus the range of permissible investments should be clearly disclosed in a Fund's offering documents. Material changes should be disclosed to a Fund's Governing Authority and investors as appropriate (Rutter Associates, 2000:21). Hedge fund managers should also supply them with standardized performance and other relevant information to all investors, such as:

- performance measures – quarterly or monthly NAV calculations and periodic profit and loss;
- capital measures – total net assets under management and net changes to capital based on new subscriptions less redemptions and the effect of profit and loss;
- annual audited financial statements;
- measures that give a view of the fund's risk such as Sharpe ratio or VaR (Rutter Associates, 2000:21).

When reporting to counterparties/credit providers, hedge fund managers should furnish periodic reports that extend trading lines or other forms or credit. The extent of disclosure can vary depending on the extent and nature of the relationship with the credit provider (Rutter Associates, 2000:21). Measures that give a view of the Fund's risk and return profile, rather than specific trading positions, should be most useful to credit providers and would not sacrifice the proprietary nature of Fund strategies and positions. Possible disclosures include:

- performance measures appropriate to the nature of the funds managed, such as periodic changes in NAV; profit and loss volatility; performance attribution by broad product classes *(e.g.,* currencies, fixed income, equities, commodities),
- capital measures – total net assets under management and net changes to capital based on new subscriptions less redemptions and the effect on profit and loss,
- market risk measures, such as Sharpe ratios, VaR or scenario- derived market risk measures for each relevant fund,

- liquidity measures, such as Cash plus Borrowing Capacity as a percentage of either equity or VaR (Rutter Associates, 2000:22).

Appropriate safeguards against counterparty's unauthorized use of proprietary information should be adopted. Hedge fund managers should provide financial and other confidential information to counterparty's credit department only and not to any member of counterparty's trading desk or department. The counterparty's credit department should confirm, preferably in a written confidentiality agreement or letter, its commitment to restrict the use of, and access to, information furnished by the hedge fund manager to the credit desk and to ensure such information is not shared with any trading personnel within the counterparty's organization or any third-party without the hedge fund manager's prior written consent (Rutter Associates, 2000:22).

When reporting to regulators, the hedge fund managers should work with appropriate governmental authorities to ensure that where large positions have a potential systemic impact, hedge fund managers along with other financial institutions and investors with significant positions comply with applicable large position reporting requirements, while preserving the confidentiality of proprietary information (Rutter Associates, 2000:22).

When making disclosures to the public, hedge fund managers should coordinate with counterparties and regulators to develop a broad consensus approach to public disclosure, evaluating both the benefits and the costs of such disclosure to investors, creditors and the markets (Rutter Associates, 2000:23).

This section examined disclosures regarding the process of hedge fund investing. In an attempt to calibrate hedge fund portfolio pricing, the construction of hedge fund indices is explained in the next section.

3.6. Hedge fund indices

Indexation can be used primarily for two major functions:

- as a form of benchmark to measure returns of active performance against a neutral benchmark of measurement, and

- as an investable index.

It is with the second category that the argument for indexation faces some tough obstacles (MarHedge, 2001:1). There are currently about ten (and still counting) providers of hedge fund indices worldwide (Morley, 2004:9). As discussed in Chapter 2, there are some problems with the indices as they all have different results for the same strategies, and they do not all agree on the categories into which hedge funds fall. Morley argued that "assuming that the hedge fund industry is around the $800 billion mark and assuming that the four main providers could each obtain $2bn of capacity with the managers in their index, then the total sum of available investable indexation would be 1% of the entire industry: The idea of serious fungibility (the ability to fully replicate in depth the underlying assets of the index) fails here. What the investable indices appear to be is another form of fund of funds offering". In the traditional world of indexation there is little argument as to what the S&P 500 or FTSE 100 (2004:1) represent[29]. The only way to create an investable index is to first create a type of fund-of-funds. This fund of funds may only invest in funds that still have capacity to invest in the sample that will be tracked. There are some problems with liquidity in such indices, i.e. when more money flows into the index how is rebalancing achieved? Another problem is what happens to the index when one of the invested funds becomes fully invested and takes no more capital. This again creates problems when new money flows into the indices. When an index is sold to an investor the index company should then buy the underlying instruments that comprise the index. This explains the problem that there can only be investable indices.

The FTSE (2004:1) has created an index and has rules to solve some of these problems, and has a database of around 6000 hedge funds to choose from. When a classification on the basis of strategy and other criteria is implemented, it reduces the database to about 250 funds. Strategic sampling reduces this to 75 funds and, after due diligence has been performed, 40 constituents remain (FTSE, 2004:1). Rules applied to the funds to determine if they will be included in the index are as follows: The funds must:

---

[29] For more information on the FTSE and S&P500, see www.ftse.com and www.S&P.com.

- have independent audited financial statements,
- have at least $50 million of unleveraged assets under management,
- have a minimum 2-year track record at the time of the annual review,
- have monthly reporting with a minimum of quarterly liquidity screening,
- be open to new investor subscriptions as well as having significant remaining investment capacity (FTSE, 2004:1).

The funds are reviewed annually in March every year in order to ensure that they still comply with established rules. But monthly reporting and risk management is done by the hedge fund manager and prime brokers. The full guide to hedge funds from the FTSE is available on the FTSE[30] (2004:1) website.

3.7. Conclusion

This chapter described the best market practice for hedge fund performance measurement in terms of risk and performance ratios, hedge fund valuation and the hedge fund indices. The fundamental definition of financial risk, the standard deviation, was introduced as a necessary prerequisite to the understanding of other risk and performance measures. Differential scaling in time of risk and return – an ubiquitous problem in fund performance measurement – was examined and an accurate solution suggested, tested and verified. The next chapter describes hedge fund portfolio risk measurement in detail.

[30] FTSE website on hedge funds indices;
http://www.ftse.com/indices_marketdata/ftsehedge/index_home.jsp;jsessionid=EE53E72AB22869CB6DD7899E20157F41

Chapter 4

Risk Measurement

4.1. Introduction

Chapter 2 discussed the origins of hedge funds and described investment strategies, whilst Chapter 3 explored hedge fund manager performance ratios. Although hedge funds have many advantages and potential rewarding characteristics (such as their diversification from traditional asset classes due to their low correlation to these asset classes) they do have some hidden risks. In this chapter some of these risks will be explored as well as different ways to measure these risks.

Particular risks are associated with hedge fund investing which have deterred investors or advisers from using them. The interesting strategies are much more complex than traditional equity and fixed income management. A significant difference between hedge funds and traditional funds is that the former are permitted to sell securities short: this introduces unique risks. *Risk management* in hedge funds, therefore, differs in some instances from traditional fund management. Hedge fund managers must also be capable of managing downside risk – an expertise that not all active managers will possess. Managing a short position is not merely the opposite of managing a long position. If a short position begins to lose money, it becomes an ever larger part of the portfolio, whereas if a long position loses money, it becomes a smaller part. This means that rigorous risk control and stop losses are crucial in the successful management of hedge funds. Risk management measures such as beta, VaR, leverage, and the incorporation of liquidity into VaR, will also be explored in this chapter.

4.2. Volatility and correlation

As explained in Chapter 3 performance measures (e.g. VaR, Sharpe and Sortino ratios) require knowledge of two important factors: volatility and correlation. Calculating these two factors is non-trivial and the accuracy with which they are measured

lends credit to the risk measures that employ them.

4.2.1. Volatility

Volatility can be measured in a variety of different ways. A brief explanation of these is given in the next section.

4.2.1.1. Simple Moving Average (SMA)

A Simple Moving Average is the average of a set of variables such as stock prices or returns over time (IVolatility, 2005:1). The term "moving" stems from the fact that, as each new price is added, the oldest price is subsequently deleted. The t-period Simple Moving Average volatility calculation first determines a t-period average of price returns. The sum of the squares of the differences between each period's return and that of the average is then determined, measured over the full T-periods. For statistical reasons, the quotient of this sum and $T-1$ is calculated and the overall square root determined. This gives the SMA volatility (also called a standard deviation). The SMA model is the most widely-used volatility model in Value at Risk studies and is given by

$$\sigma = \sqrt{\frac{1}{T-1}\sum_{t=1}^{T}(r_t - \bar{r}_a)^2}\,. \qquad \textbf{4-1}$$

(Hull, 2000:242)

Where:

σ is the Simple Moving Average volatility measure

T is the number of observations

r_t is the observation (return in this case) at time index t

$\bar{r}_a$ is the mean, or expected value of all observations (Klugman *et al.*, 1998:31)

The disadvantage of the SMA is that it is inherently a memory-less function. A large increase or rise in the price (and the corresponding surge in price return) is "forgotten" and does not manifest itself quantitatively in the simple moving average as can

be seen in Figure 4.1 below.

The calculation of volatility using the SMA technique does not take into account the time order of observations. Additionally, all observations have equal weights in the formulas, namely $1/(T-1)$.

The SMA does not distinguish recent data from data in the distant past. The most recent data (the asset's price return), however, are more important for volatility forecasting than data that occurred at some time in the past. Recently-recorded statistical data should thus be assigned greater weight for forecasting purposes than older data. One model that operates according to this design is the Exponentially Weighted Moving Average: a special case of a generalised ARIMA (Auto Regressive Integrated Moving Average) model.

4.2.1.2. Exponentially Weighted Moving Average (EWMA)

The most recent price return data are more important for forecasting and accurate measurement of contemporary risk measures than data that occurred in the past. This section presents the J.P. Morgan RiskMetrics© approach to estimating and forecasting volatility that uses an exponentially weighted moving average model (JP Morgan, 1996:68).

The EWMA model calculates a volatility on the basis of the previous day's value (and that value depends on the previous day's value before it, and so on). The EWMA model thus enjoys an advantage over the SMA since the EWMA technique retains a memory of past occurrences. The EWMA "remembers" a fraction of its past by a calculated factor, λ, making the EWMA a good indicator of the history of the price movement if a measured choice of the term is made. The exponentially weighted moving average of historical observations captures the dynamic features of volatility: the model employs the most recent observations by applying the highest weights to these in the calculation of the volatility.

The EWMA model depends on the parameter λ (where $0 < \lambda < 1$), referred to as the decay factor. This parameter defines a relative weight $(1-\lambda)$, that is applied to the most recent volatility and a weight of λ to the most recent price return. The pa-

rameter also defines the effective amount of data used in estimating volatility. The higher the value (i.e. closer to 1), the less the most recent observation affects the current dispersion estimation. The rate of return to the previous volatility level is also determined by λ. The higher the value (i.e., closer to 1), the faster the dispersion returns to the previous level after strong return change. The optimal value for daily volatility of returns in the South African market was calculated as $\lambda = 0.925$ (Botha *et al.*,1999:18 – 23 & Van Vuuren *et al.* 2000:23), but as shown by these authors, λ changes significantly in time and may now (2005) conceivably be higher. For a value of $\lambda = 0.925$, the EWMA volatility may be accurately calculated on the basis of 50 observations. The calculation of λ is outside the scope of this dissertation.

The formula of the EWMA model can be re-arranged to take the following form:

$$\sigma_t^2 = (1-\lambda) \cdot \sum_{t=1}^{\infty} \lambda^{t-1} \times r_{t-1}^2 . \qquad \textbf{4-2}$$

(Hull, 2000:240)

where σ_n^2 is the t^{th} period volatility,

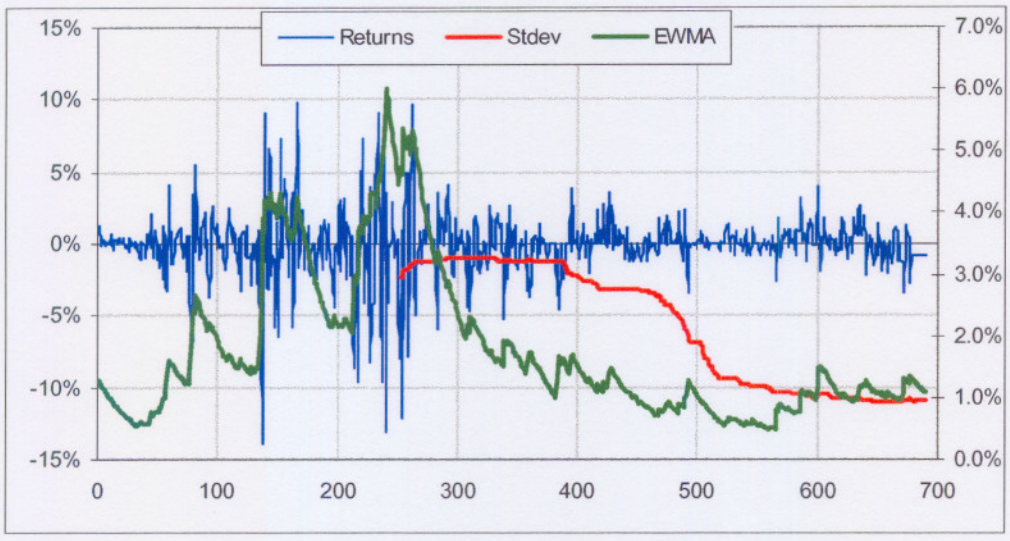
λ is the decay factor and

r_{t-1}^2 is the $t-1^{\text{th}}$ period squared return.

Returns that occur more distantly in the past (i.e., ones further away from the present time or time of measurement) have lower assigned weights, which are close to zero. Note that, in the SMA (Equation 4-1) all returns have same weight: $1/(T-1)$

Figure 4.1 below shows the difference between the Simple Moving Average (shown as a red line) and the Exponentially Weighted Moving Average (shown as a green line) for a set of price return data with a large perturbation occurring at time index $t = 130$ and then a sustained burst of activity from $t = 210$ to $t = 260$.

Figure 4-1 Comparison of volatility as measured by the SMA and EWMA techniques.



(IVolatility, 2005:1)

Van Vuuren *et al.,* (2000:22 – 25) and Botha *et al.,* (2001:24 – 32) showed that $\lambda = \lambda(t)$ and is itself highly variable in time. Calculating λ on a daily, weekly or monthly basis is straightforward and provides an improvement to the already-enhanced accuracy provided by this technique.

A third method of volatility estimation is the Generalised AutoRegressive Conditional Heteroskedasticity (GARCH) model – a special case of a generalised ARCH (Auto-Regressive Conditional Heteroskedastic) model.

4.2.1.3. Generalised AutoRegressive Conditional Heteroske-dasticity (GARCH)

GARCH (Generalised Autoregressive Conditional Heteroskedasticity) is another model that may be used to measure volatility and correlation. Heteroskedasticity re-fers to time-varying variance (hence time-varying volatility), "conditional" implies a dependence on the observations of the immediate past, and "autoregressive" describes a feedback mechanism that incorporates past observations into the present (Hull, 2000:245). GARCH, then, is a mechanism that includes past variances in the explana-tion of future variances. More specifically, GARCH is a time-series technique that allows users to model the serial dependence of volatility. GARCH models are para-

metric specifications that operate best under relatively stable market conditions (Engle *et al.*, 2001:1).

GARCH modelling builds on advances in the understanding and modelling of volatility in the last decade. It takes into account excess kurtosis (i.e., fat tail behaviour) and volatility clustering – two common and important characteristics of financial time series (IVolatility, 2005:1). It provides accurate forecasts of variances and covariances of asset returns through its ability to model time-varying conditional variances (and hence volatilities). Although GARCH is explicitly designed to model time-varying conditional variances, GARCH models often fail to capture highly irregular phenomena, including large market fluctuations and other highly unanticipated events that can lead to significant structural change (Kwan *et al.*, 2005:1). GARCH models also often fail to fully capture the fat tails observed in asset return series. Heteroscedasticity explains some of the fat tail behaviour, but typically not all of it. To compensate for this limitation, fat-tailed distributions such as Student's t have been applied to GARCH modelling (Palandri, 2004:1).

It is important to note that GARCH models are only part of a volatility and correlation measurement solution. Although GARCH models are usually applied to return series, financial decisions are rarely based solely on expected returns and volatilities.

A comparison between GARCH and EWMA volatility estimates is shown below in Figure 4.2 using South African price return data from the JSE between October 2000 and July 2003.

The GARCH model (Hull, 2000:247) is calculated from a long-run average variance rate, V_L, as well as from σ_{n-1} and u_{n-1}. GARCH volatility is given by:

$$\sigma_n^2 = \gamma V_L + \alpha u_{n-1}^2 + \beta \sigma_{n-1}^2, \qquad \textbf{4-3}$$

where γ is the weight assigned to V_L,

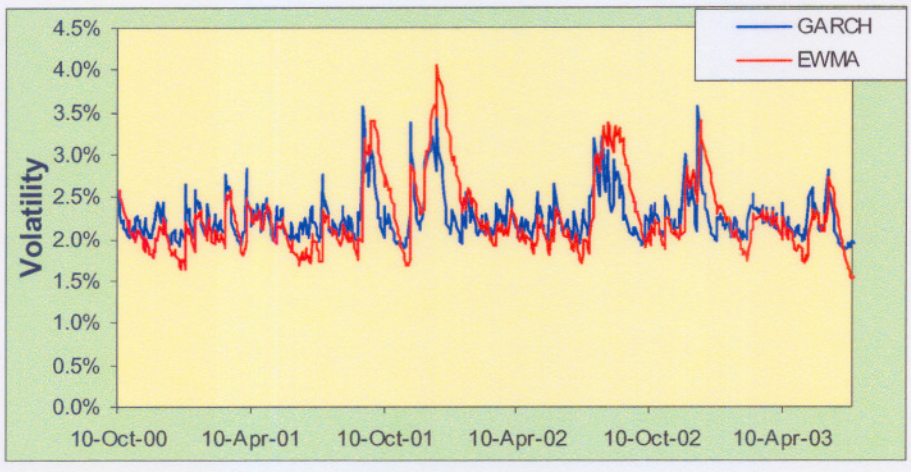
α is the weight assigned to u_{n-1}^2, and

β is the weight assigned to σ_{n-1}^2.

Since the weights must sum to 1,

$$\gamma + \alpha + \beta = 1. \qquad 4\text{-}4$$

Figure 4-2 A comparison of volatility calculated using the EWMA and GARCH methods.



(IVolatility, 2005:1)

The EWMA model is a particular case of the GARCH model where $\gamma = 0$, $\alpha = 1 - \lambda$, and $\beta = \alpha$. Volatility is an important measure of measuring risk and therefore it is important to calculate it as accurately as possible. In addition to the level of price return volatility, the degree of comovement, or correlation, between price return series is of critical significance. This will be discussed in the next section.

4.2.2. Correlations

The correlation between two variables reflects the degree to which the variables are related (IVolatility, 2005:1). The most common measure of correlation is the Pearson Product Moment Correlation (or Pearson's Correlation). Pearson's correlation reflects the degree of linear relationship between two variables and numerically can assume any value between -1 and +1 depending upon the degree of the relationship (Hull, 2000:249). Plus and minus one indicate perfect positive and negative relationships respectively whilst 0 indicates that the variables do not co-vary in any linear fashion.

Many financial variables have been found to co-vary. The degree of co-movement between return variables is particularly important for risk measurement (in particular the Value at Risk calculation), for hedging and asset allocation. Correlation is calcu-

lated in many different ways – the most common method uses an equation very similar to that used for variance, namely:

$$\rho = \sqrt{\frac{1}{T-1}\sum_{t=1}^{T}(x_t - \bar{x})\cdot(y_t - \bar{y})} \qquad \textbf{4-5}$$

(Hull, 2000:242)

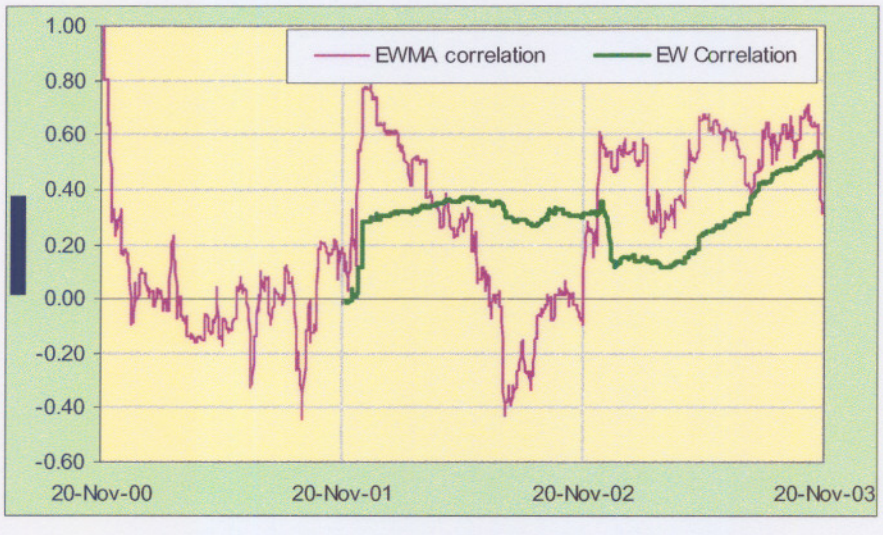
where ρ is Pearson's correlation,

T represents the entire observation period and

x_t and y_t are the two different return variables, generated from two price series. The overbar reflects the average of the relevant quantity.

Exponentially Weighted Moving Average correlations and GARCH correlations may also be calculated. The mathematics of these techniques lie outside the scope of this dissertation but are discussed in more detail in Hull (2000:246). A comparison of SMA correlation (Pearson's correlation) and that calculated using the EWMA technique is given below in Figure 4.3.

Figure 4-3 A comparison of SMA (or equally weighted- EW) and EWMA correlation.



(IVolatility, 2005:1)

Figure 4.3 shows that the EWMA correlation adjusts more rapidly and more acutely to a sudden change in the return of an instrument than the SMA (equally weighted)

method. This is similar to the effect observed for the EWMA and SMA volatilities.

Volatility and correlation are important measures in finance. Their measurement has implications for the pricing of instruments, the calculation of risk measures (e.g., VaR and several performance ratios) and the Black Scholes model for option pricing. Volatilities and correlations are employed for the measurement of beta – discussed in the following section.

4.3. Beta

4.3.1. Introduction to beta

Volatility and correlation are used to calculate beta. A measure of the sensitivity of price returns to local market returns is both an important component of risk management as well as a necessary element of the Capital Asset Pricing Model (CAPM) formulation of asset allocation (Mathiesen, 2004:1). Such a sensitivity is known as beta, or β, and it measures the extent to which a given fund's returns have vary in line with movements in benchmark returns (AIMA, 2002:3).

VAN Hedge Fund Advisors are critical of the measure, stating:

> "Beta, beloved of academics, is of limited value in the measurement of risk in hedge funds. Beta measures the extent to which the return of an investment moves with market return. It can be very useful with unhedged stock portfolios, the movements of which tend to be fairly highly correlated with market movements. However most hedge funds are not highly correlated with equity market movements and therefore their Betas have limited usefulness." (VAN Hedge Fund Inc, 2002:1).

Kazemi and Schneeweis (2003:23), however, assert the counter-claim that beta *is* an important quantity in the allocation of market risk amongst managers. Whilst the debate continues (see, for example, Damodaran, (2003:1) and Scott and Zemciky, (2002:2)), beta has proved to be a useful measure in determining the market exposure of long short hedge funds, but as with any risk measurement tool it is maximally employed in conjunction with other measures. The calculation, pros and cons and limitations of beta are discussed in the next section.

4.3.2. Beta: Background information

Beta measures the sensitivity of an instrument or portfolio's return in relation to a market or index. This section provides more background information on this measure.

Beta is one of the components of the CAPM: a linear regression model that explains an instrument's return behaviour in comparison with that of the market (Mathiesen, 2004:1). The CAPM employs several assumptions:

- Investors make decisions solely in terms of expected value, standard deviation and the correlation structure having a one period horizon.
- No single investor can affect prices by one action - prices are determined by the actions of all investors in total.
- Investors have identical expectations and information flows perfectly.
- There are no transaction costs.
- Unlimited short sales are allowed.
- Unlimited lending and borrowing at the risk-free rate is possible.
- Assets are infinitely divisible (Mathiesen, 2004:1)

The equation which governs the returns generated using CAPM is given by:

$$r = R_f + \beta \cdot (K_m + R_f) \qquad \textbf{4-6}$$

(Bodie *et al.*, 1999:286)

where:

r is the expected return rate on a security;

R_f is the return of a "risk-free" investment, i.e. cash

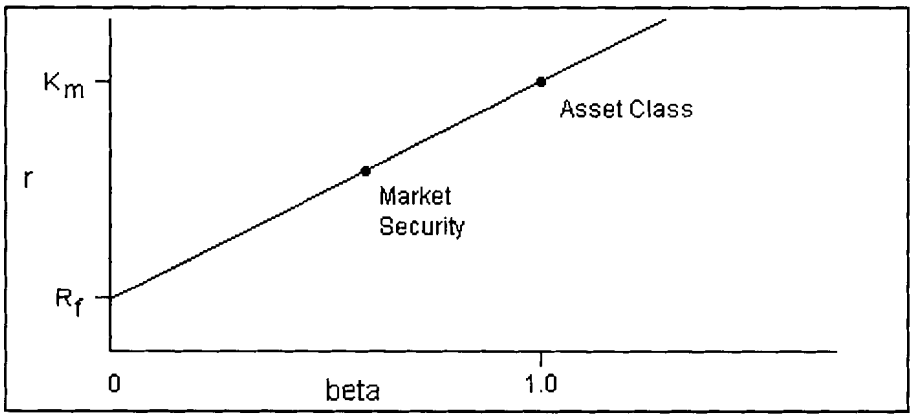
β is the asset beta and

K_m is the return of the relevant asset class (Jackson *et al.*, 2004:100)

Equation 4-6 asserts that investors require higher levels of expected return to compen-

sate them for taking on higher expected risk. The expected return of a security may be seen as a function of beta and is shown below in Figure 4.4.

Figure 4-4 Portfolio return as a function of beta



(Jackson *et al,* 2004:103)

In addition to being a measure of return relative to a market, beta provides a comparison of the volatility of a security relative to that of an asset class and may also be calculated as follows:

$$\beta_i = \frac{Cov(r_i, r_M)}{\sigma_M^2} \qquad \textbf{4-7}$$

(Bodie *et al.,* 1999:754)

where the covariance (*Cov*) between r_i (the returns of the i^{th} instrument) and

r_M (the market returns) is given by:

$$Cov(r_i, r_M) = \rho_{i,M}\sigma_i\sigma_M \qquad \textbf{4-8}$$

(Bodi.e., *et al.,* 1999:754)

where

$\rho_{i,M}$ is the correlation between returns of the i^{th} instrument and those of the market,

σ_i is the volatility of the returns of the i^{th} instrument and

σ_M is the volatility of the market returns.

Two critical factors to consider when calculating beta are volatilities and correlations. The accuracy of the estimate of beta is only as good as the accuracy of the estimate of these two factors.

Section 4.2 provided descriptions of various methods to calculate volatility and correlation. The different measures of volatility and correlation can therefore result in different measures of beta. Beta may be represented as a Simple Moving Average (SMA) beta, an Exponentially Weighted Moving Average (EWMA) beta and a Generalised Auto Regressive Conditional Heteroskedasticity (GARCH) beta.

Liquidity also plays a role in the determination of beta. Assets with diminished liquidity often understate risk estimates, including beta (Clermont, 2003:1). Hedge funds are well-known for investing in illiquid assets in the search for greater return. A careful consideration of calculated beta values must therefore prevail if they are to be of any lasting value in hedge funds.

The use of beta to determine market exposure must also be undertaken with caution: a good understanding of the calculation of beta results in a better use of the value. Beta is often used for this purpose in hedge funds, more specifically with Long Short funds.

4.3.3. Beta as a market exposure tool for hedge funds

As discussed in Section 4.3, long short funds employ beta to determine the extent that the fund returns moves with market returns. Market neutral strategies (as part of long short strategies) can imply Rand-neutral, beta-neutral or both.

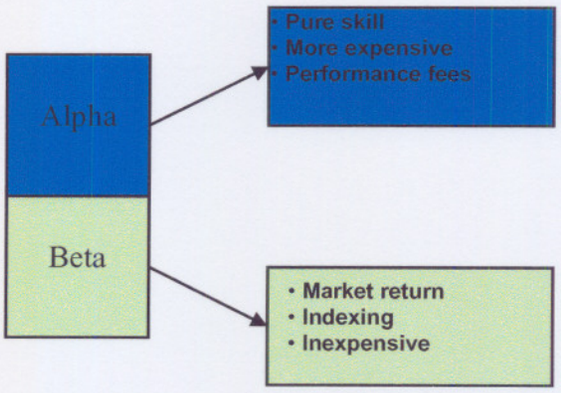
- Rand neutral strategies have zero net investment (i.e., equal Rand amounts in long and short positions)
- Beta neutral strategies target zero total portfolio beta (i.e., the beta of the long side equals the beta of the short side). While Rand neutrality has the virtue of

simplicity, beta neutrality better defines a strategy uncorrelated with the market return (Jorion, 2004:90).

Many practitioners of market-neutral long short equity trading balance their long positions and short positions in the same sector or industry. By being sector neutral, they avoid the risk of market swings affecting some industries or sectors differently from others. This is a popular strategy both within the South African environment and the rest of the world.

Hedge funds have two main sources of return, namely alpha and beta (Clermont, 2003:2). Alpha is a fund's excess return, or return generated when the market returns are zero. Even when the underlying market itself does not move, the fund still generates a return – or *excess* return. Alpha is an inherent component to the CAPM and it may be derived directly from Equation 4-6 above. The main differences between alpha and beta are shown schematically in Figure 4.5 below.

Figure 4-5 Schematic representation of the two sources of asset return.



(Clermont, 2003:2)

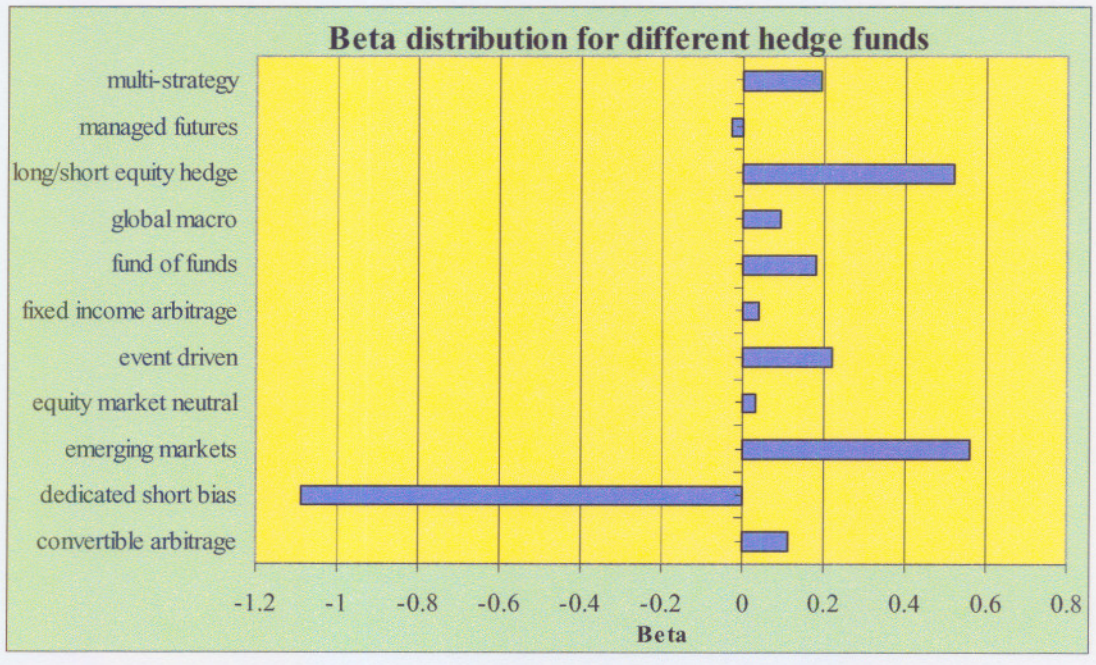
Alpha reflects the investing skill of the fund manager responsible for the fund whilst beta is the fund's return relative to that of the market. An analysis of the returns of hedge fund strategies shows that most funds are *not* market neutral, that is, they are not pure alpha strategies (AIMA: 2002:14).

Beta is a cheap constituent of overall hedge fund return generators: there are a few "excellent index managers who can deliver market returns inexpensively" (Clermont, 2003:2). Alpha derived directly from skill alone is expensive and many hedge fund

fees reflect this – typically involving higher base fees plus a performance fee. Higher fees are generally paid for skill (i.e., alpha) rather than for beta (Clermont, 2003:2). This is not an easy task as most long short hedge funds enjoy a mandate to tilt[31] the portfolio from time to time to take advantages of market upswings and downturns and this in itself may be considered a skill. Beta distributions for different types of hedge funds (explained in Chapter 2) behave very differently.

Figure 4.6 presents summary information on beta distribution information of portfolios of hedge funds in the TASS dataset sorted by styles and certain characteristics (Bailey *et al.,* 2004:33). As expected market neutral funds are almost beta zero, although most long short funds have a positive beta and therefore have some correlation with the market. Dedicated short bias has a large negative beta because of the large short positions the fund takes.

Figure 4-6 Summary beta distribution information on portfolios of hedge funds.



(Bailey *et al.,* 2004:33)

[31] Tilting a portfolio is to change the exposure of the fund.

4.3.4. Summary

Beta is a solid measure of market exposure risk in hedge funds, but as with all other risk measures it *must* be used in conjunction with other measures to derive its maximal benefit. The measurement of beta must also be undertaken with care, because of the subtleties and intricacies of volatility and correlation measurement. Volatility and correlation is also used in calculating Value-at-Risk and will be discussed in the next section.

4.4. Value at Risk

The volatilities and correlations of instruments have been discussed, as well as the effect of these on beta. An important measure in financial risk management is value at risk (VaR), which combines many disparate risk parameters into a single value. This important concept will be discussed in this section.

4.4.1. Introduction

VaR may be described as follows:

> "Value at risk (VaR) is a single, summary statistical measure of possible portfolio losses. Specifically, VaR is a measure of losses due to normal market movements. Losses greater than the VaR are suffered only with a specified small probability. Subject to the simplifying assumptions used in its calculation, VaR aggregates all of the risks in a portfolio into a single number suitable for use in the boardroom, reporting to regulators or disclosure in an annual report. Once one crosses the hurdle of using a statistical measure, the concept of VaR is straightforward to understand. It is simply a way to describe the magnitude of the likely losses on the portfolio" (Linsmeier & Pearson, 1996:12).

The choice of VaR parameters and different techniques for measuring VaR are given in following sections.

4.4.2. VaR calculations

The calculation of VaR may be performed in three different ways. In this section an explanation of each will be given, as well as some insight into the advantages and dis-

advantages of each, where they are most likely to be used and why they may not be used. The three methods are

- the historical method
- the variance-covariance method and
- the Monte Carlo simulation method (Fischer Investments, 2001b:1).

A summary comparing the three methods concludes the section.

4.4.2.1. Historical method

The historical simulation approach is the first of the three different ways to calculate portfolio VaR. The main idea behind this method is to use the historical distribution of returns of the individual assets in the portfolio to simulate the portfolio VaR, on the hypothetical assumption that this portfolio is held over the period of time covered by the historical data set (Yieldcurve.com, 2003:4).

To apply this approach, the following steps must be applied:

- The portfolio positions must be identified. An equation to express the mark to market price of each position must also be determined.
- A sample of the instruments historic returns must be obtained over some observation period. The observed period may be decided by the risk manager.
- The weights in the portfolio must be used to simulate the hypothetical returns that would have been obtained though time if the weights of the position in the portfolio had been constant through the holding period.
- The historical returns of the portfolio through time are then assumed to be a good proxy for how the portfolio will behave in future periods. Portfolio profits and losses-generated from a full revaluation of current positions and historically simulated returns must be sorted from the largest loss to the largest profit.
- The relevant percentile from the distribution of historical returns then leads to the expected VaR for the current portfolio (Linsmeier & Pearson, 1996:8).

These steps are also explained mathematically as follows. Assume t observations run from period 0 to period T, R_i is the return for asset i over period t, w is the relative weight of assets i in the portfolio and there are n assets in the portfolio. The portfolio return R_t^p over period t is:

$$R_t^p = \sum_{i=1}^{n} w_i R_i . \qquad t = 0,\ldots,T \qquad \textbf{4-9}$$

(Pritsker, 2001:11)

Each observation t results in a particular portfolio return R_t^p. The sample of historical observations therefore gives a sample distribution of (hypothetical) portfolio returns. The portfolio returns are then transferred into profits and losses, and the VaR is then read of the histogram of the portfolio. For example, if a sample of 1 000 daily observations were taken and the VaR were based on a 95% confidence level, it would be expected that the actual losses would exceed the VaR on 5% of days, or 50 days in total, is the 51st highest loss (Dowd, 1998:99).

The historical method is based on actual results and if, during the historical period, major market events occurred, these would be accurately assigned by the historical method. This method of calculating VaR, as with any other method has some advantages and disadvantages. These are discussed in the following section.

4.4.2.1.1. Advantages of the Historical method of calculating VaR

The historical method has a number of attractions:

- it is conceptually simple, a feature that not only helps risk managers, but it is also easy to report this to senior management,
- much of the necessary data should be available from public sources or already stored in-house,
- historical simulation is easy to implement and can usually be implemented in a spreadsheet.
- it does not depend on assumptions about the return distributions. Because the

historical method uses actual historical returns of the instruments to calculate portfolio returns over time, there is no need to make assumptions such as the normal distribution of returns or that returns are independently distributed. Therefore the historical method has no problem accommodating fat tails in the distribution,

- there is no need to estimate volatilities and correlations with this method. There is therefore no risk of estimating these incorrectly, and calculating incorrectly the variance covariance matrix (discussed in Section 4.4.2.2),
- it applies to any type of instrument and any type of market risk. It therefore accommodates volatility risk and similar risks that parametric approaches (discussed in Section 4.4.2.2 and Section 4.4.2.3) have difficulty with,
- it takes into account other important statistical measures. Since VaR is read off a historical distribution, the distribution takes account of skewness, kurtosis, expected tail losses for any given size of tail, and VaR estimates based on alternative confidence levels (Dowd, 1998:133).

4.4.2.1.2. Problems with the Historical method of calculating VaR

The historical method, as with all other methods of calculating risk measures, is not perfect and has several limitations.

- Correct data. This is a problem with any approach of calculating VaR and not only the historical method. The historical method requires adequate runs of data for each instrument in the portfolio.
- A considerable drawback of the historical method is its complete dependence on historical results of the particular historical data set. The assumption is made that the past will repeat itself. This can lead to some distortions in VaR, in a number of circumstances:
    - Data in the estimation period might be unusual. Data might have been obtained from a quiet period which will underestimate VaR
    - The estimation period may incorporate unusual events (for example a market crash). This effect will remain in the dataset until it falls out of

the estimation period. If five years of data is used for estimating VaR the effect of the unusual event will remain in the data set for a period of five years. This will result in a overestimation of VaR, when the event falls out of the data set used (five years later) the VaR will suddenly decrease without any contemporary change to the portfolio returns.

- The historical method has difficulty dealing with permanent changes in risk factors. If a permanent change takes place (e.g., there is an exchange rate policy change) it only gradually takes this into account as new data starts entering the data series and the old data falls out. The effect will again only be completely history if all of the old data (before the change took place) are replaced by data after the event.
- It is very unlikely that historical VaR can be forecasted correctly by simply observing historical events. If an event has not yet occurred in the past, it will not be taken into account in the VaR number.

- Problem of estimation period length

  A reasonable set of data is required to have enough observations from which to draw reliable inferences about the tail of the distributions. Since tail events are unusual by definition, a large number of these events are needed for a reasonable VaR. If the VaR is based on a 95% interval, only one in every 20 days may be used as a loss event. If VaR is based on a 99% confidence interval, one in every 100 days may be used as a loss event. Therefore, the longest possible period of data is required to maximise the accuracy of the results, but data often have systematic changes, and then shorter periods of data are preferred.

- Potentially unreliable VaR estimates
  - The empirical result of Butler and Schachter (1996:10) indicated that VaR estimates varied considerably in their accuracy,
  - VaR estimates become more unreliable as confidence intervals increase. This is mainly due to sample size (Dowd, 1998:139).

Historical VaR has its advantages and disadvantages, but it is mostly used because of its ease of use and comprehensibility. Hedge funds use historical VaR usually in less

complex strategies and where much data are available. Other methods of calculating VaR are discussed in the next section.

4.4.2.2. Variance covariance method

This section evaluates the calculation of VaR with respect to the variance covariance method. All risks are normal and the portfolio is a linear function of these risks (Dowd, 1998:63).

The components of VaR from a variance covariance (VCV) point of view are shown below. These components are the basic inputs to the VaR VCV equation.

Table 4-1 Basic VaR Equation

Volatility Correlation VaR =

Position size (N)

(number of units)

$\times$

Unit price sensitivity to market factors

(market factor deltas)

$\times$

Potential volatility of market factors (σ, ρ)

(correlation of observed probability distributions of market factors)

$\times$

Confidence level of volatility estimation (CI)

(number of standard deviations of probability distribution)

$\times$

Holding period horizon extrapolation (T)

(square root of number of days)

4-10

(Payant, 1996:23)

Different approaches to estimate VaR using this method as well as the parameters that constitute it are discussed in the next section.

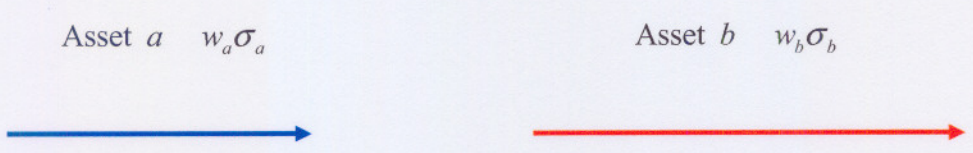
VaR comprises a multiple of portfolio standard deviations: a linear function of individual volatilities and covariances. Portfolio VaR is therefore a matter of employing the variance covariance matrix and information on the size of the individual positions in order to determine the portfolio standard deviations. Multiplying this standard deviation by a confidence interval parameter and a scale variable reflecting the size of the portfolio (Holton, 2003:40) gives an overall VaR measurement.

The covariance matrix is the basis of the calculation of the variance covariance VaR method. The determination of portfolio risk using vector addition and the manner in which this fits into the variance covariance matrix will now be discussed. In addition, the covariance matrix will be defined and calculated in this Section.

Total portfolio risk can be calculated using vector addition – a concept borrowed from vector physics. This is not a common explanation, but its usefulness to the understanding of the idea behind the variance covariance matrix cannot be underestimated. From the portfolio risk, VaR may be easily calculated, as shown in Section 4.4.

Suppose a portfolio P comprises two assets, a and b, making up the portfolio in such a way that a has a weight of w_a and b has a weight w_b. Asset a has a volatility σ_a and b has a volatility σ_b (Archer, 2005:1). Volatilities *represented by vectors* for assets a and b of length σ_a and σ_b and weighted by w_a and w_b are shown in Figure 4.7 below.

Figure 4-7 Vector representation of volatility.

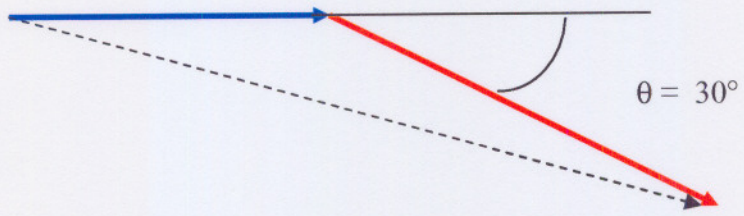


(PhysicsNet, 2005:1)

The risk (standard deviation) of asset a and asset b cannot be arithmetically summed because these two assets might have some co-movement in the same or opposite di-

rection (or any other "direction"). The addition of vector quantities requires knowledge of a correlation (ρ_{ab}) between them, i.e., they sum vectorially, as shown by the dotted line in Figure 4.8.

Figure 4-8 Vector addition with correlation between vectors.



(PhysicsNet, 2005:1)

Figure 4.8 shows the vector sum relationship graphically. The ρ relationship is represented by calculating the cosine (cos θ) of the external angle shown in Figure 4.8. Suppose that the correlation is $\rho = 0.886$, then the cosine of the angle $\theta = 0.886$ or $\theta = 30°$. The total portfolio risk – taking into account the volatility of assets a and b, as well as the correlation between a and b – is given as a dotted line in Figure 4.8 (PhysicsNet, 2005:1).

The effect in Figure 4.8 is represented mathematically as:

$$\text{Portfolio risk} = \sqrt{(w_a\sigma_a)^2 + (w_b\sigma_b)^2 + 2w_a w_b \sigma_A \sigma_B \cos\theta}\,. \qquad \textbf{4-11}$$

(Finnegan, 2005:2).

This is the standard "cosine rule" – well-known in physics and linear algebra (PhysicsNet, 2005:1). An easier way to represent (and hence calculate) this quantity is to make use of matrices and linear algebra. The weights of the assets, a and b are matrix multiplied by the variance/covariance matrix between these two assets.

A first step requires the determination of the covariance matrix, which itself involves determining the variances (σ^2) of both a and b as well as the covariances between them. This again may be undertaken by employing the SMA method, the EWMA method or GARCH as indicated in Section 4.2. The method used to calculate correla-

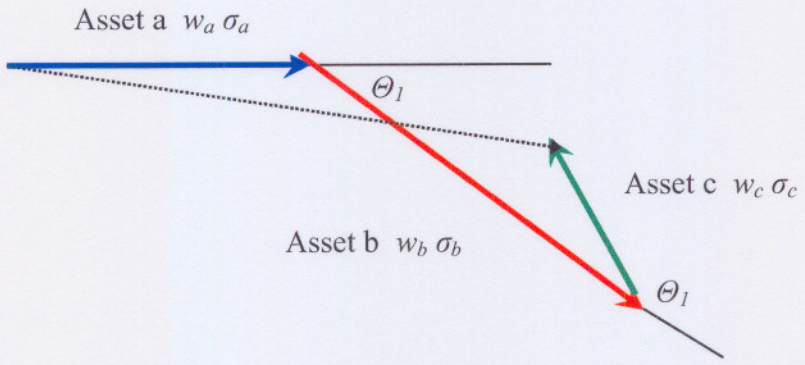
tion between a and b must be the same method as that used to calculate the volatility. A covariance matrix can then be calculated as follows.

Covariance matrix

	Asset a	**Asset** b
Asset a	σ_a^2	$\sigma_a \sigma_b \rho_{ab}$
Asset b	$\sigma_a \sigma_b \rho_{ab}$	σ_b^2

When there are more than two assets in the portfolio, for example assets a, b and c, the portfolio risk then becomes the doted line in Figure 4.9.

Figure 4-9 Graphical vector addition representation of three vectors.



(PhysicsNet, 2005:1).

The quantities θ_1 and represent the correlations between (a and b) and (b and c) respectively.

The matrix multiplication (vector sum) is now:

$$\text{Portfolio std dev} = \sqrt{\begin{pmatrix} w_a & w_b & w_c \end{pmatrix}\begin{pmatrix} \sigma_a^2\rho_{aa} & \sigma_a\sigma_b\rho_{ab} & \sigma_a\sigma_c\rho_{ac} \\ \sigma_b\sigma_a\rho_{ba} & \sigma_b^2\rho_{bb} & \sigma_b\sigma_c\rho_{bc} \\ \sigma_c\sigma_a\rho_{ca} & \sigma_c\sigma_b\rho_{cb} & \sigma_c^2\rho_{cc} \end{pmatrix}\begin{pmatrix} w_a \\ w_b \\ w_c \end{pmatrix}}$$

$$= \sqrt{\begin{matrix} w_a^2\sigma_a^2\rho_{aa} + w_a w_b\sigma_b\sigma_a\rho_{ba} + w_a w_c\sigma_c\sigma_a\rho_{ca} + w_b w_a\sigma_a\sigma_b\rho_{ab} + w_b^2\sigma_b^2\rho_{bb} \\ + w_b w_c\sigma_c\sigma_b\rho_{cb} + w_c w_a\sigma_a\sigma_c\rho_{ac} + w_c w_b\sigma_b\sigma_c\rho_{bc} + w_c^2\sigma_c^2\rho_{cc} \end{matrix}}$$

$$= \sqrt{\begin{pmatrix} w_a\sigma_a^2\rho_{aa} + w_b\sigma_b\sigma_a\rho_{ba} + w_c\sigma_c\sigma_a\rho_{ca} + \\ w_a\sigma_a\sigma_b\rho_{ab} + w_b\sigma_b^2\rho_{bb} + w_c\sigma_c\sigma_b\rho_{cb} + \\ w_a\sigma_a\sigma_c\rho_{ac} + w_b\sigma_b\sigma_c\rho_{bc} + w_c\sigma_c^2\rho_{cc} \end{pmatrix}\begin{pmatrix} w_a \\ w_b \\ w_c \end{pmatrix}}$$

4-12

Because $\rho_{aa} = \rho_{bb} = \rho_{cc} = 1$, $\rho_{ab} = \rho_{ba}$, $\rho_{ac} = \rho_{ca}$ and $\rho_{bc} = \rho_{cb}$, Equation 4-12 may be rewritten a follows.

$$\text{Portfolio volatility} = \sqrt{\begin{matrix} w_a^2\sigma_a^2 + w_b^2\sigma_b^2 + w_c^2\sigma_c^2 + \\ 2w_a w_b\sigma_b\sigma_a\rho_{ba} + 2w_a w_c\sigma_c\sigma_a\rho_{ca} + 2w_b w_a\sigma_a\sigma_b\rho_{ab} \end{matrix}}$$

4-13

(Finnegan, 2005:3).

Section 4.2 described the calculation of VaR and Equation 4-13 may now be applied to Equation 4-10 above to give overall portfolio VaR.

The accuracy of the variance covariance method of calculating VaR relies heavily on the correct estimation of the volatilities and correlations that is used in the covariance matrix.

The variance covariance method makes certain assumptions, namely:

- price returns are normally distributed,
- historical volatilities and correlations are preserved,
- changes in the price of the portfolio, due to changes in the underlying risk factors, are linear,
- there is no convexity of portfolio price return changes (hence this method is sometimes called the delta-normal approach) and

- returns are statistically uncorrelated (i.e., there is no autocorrelation between returns from one measurement period to the next) with each other and therefore that an n-period volatility (as derived from a one period return series) is given by $\sqrt{n} \times \sigma_1$ where σ_1 is the one period volatility (van Vuuren, 2005).

This method of calculating VaR has several advantages and disadvantages.

4.4.2.2.1. Advantages of the variance covariance method

- The variance covariance method is tractable and comprehensible; the concept of VaR is easily understood by management,
- it has a simple equation for calculating VaR ($VaR = N \times \sigma \times CI \times \sqrt{T}$)
- it is a smooth, well-behaved continuous function,
- much information is conveyed by normal VaR,
- it is relatively simple to handle incremental VaR,
- it is ideal for linear positions in normal risk factors, and
- the central limit theorem applies even if the risks are not normal, provided they are numerous and independent (Dowd, 1998:138).

4.4.2.2.2. Disadvantages of the variance covariance method

- The dependence on the normality assumption, and evidence that returns are not normal (leptokurtosis and fat tails),
- it can be very misleading if returns are not normal – VaR underestimated. etc
- it is not suited to the handling of optionally or non-linearity,
- positions must be mapped to known node points when considering VaR for fixed income instruments,
- delta-gamma approaches are difficult to implement and not necessarily much better than delta-normal, and
- there are problems with extreme events unless extreme value theory is applied (Dowd, 1998:133).

The variance covariance method is a method that is also widely used in the asset management industry. Database companies supply the variance covariance matrix (or at least the components that are used for the calculation of the variance covariance matrix) regularly (e.g., RiskMetrics). From these matrices, the remainder of the calculation is easily implemented.

Another method of calculating VaR is the Monte Carlo simulation method. This is discussed in the next section.

4.4.2.3. Monte Carlo simulation method

This section deals with the Monte Carlo simulation method of estimating VaR. This method is derived from statistical or mathematical models that simulate changes in parameters required to price the underlying variable (Staum, 2002:2). Each simulation gives a possible value for the financial instrument at the end of the target horizon. If enough of these simulations are taken into account then the simulated distribution of portfolio values will converge to the portfolio's unknown true distribution and the simulated distribution can be used to infer the VaR of the true one (Dowd, 1998 :108).

This is best explained using for a single instrument and then building the description to embrace multiple instruments.

4.4.2.3.1. Steps for a single instrument

Any instrument may be used, but for illustrative purposes, a single stock was chosen.

- Step 1

  The first step is to identify market factors and obtain an equation linking the mark to market value of the stock to these market factors. For stocks this may be the last traded price for the day or a volume traded price, but for other instruments such as forwards, a mathematical model must be determined to arrive at a mark to market value (Linsmeier & Pearson, 1996:8).

- Step 2

  The second step is to determine specific distributions for changes in the market factors and to estimate parameters for these distributions. The selection of the

distribution is the key feature that distinguishes Monte Carlo simulation from both the historical and the variance covariance method. In both other techniques the distribution of changes in the market factors is specified as part of the method.

The assumed distributions need not be multivariate normal, though the natural interpretations of their parameters (means, standard deviations, and correlations) (see Section 4.2) and the ease with which these parameters can be estimated, weigh in their favour. The risk manager is free to choose any distribution that reasonably describes the possible future changes in the market factors. These assumptions of possible future changes in market factors are typically based on observed past changes (Glasserman, 2002:242).

- Step 3

  Once a distribution has been selected, the next step employs a random number generator to generate N hypothetical values in market factors where N is usually greater than 1000 and often greater than 10 000 for statistical significance (Wikramaratna, 2000:2). The hypothetical market factors are then used to calculate N hypothetical portfolio return values. These values are then subtracted from the actual market value of the portfolio on that day, thereby giving a set of N portfolio profit and losses.

- Step 4

  The next step is to order the mark to market profit and losses for the N scenarios generated in step 3, from the largest losses to the largest profits.

- Step 5

  For a 1000 simulation approach and a 95% confidence interval, VaR is the 50^{th} largest loss in the series of losses ordered in Step 4. Equally for a 10 000 scenario simulation the 95% confidence interval will be the 500^{th} largest loss, and for a 99% confidence interval it will be the 100^{th} largest loss.

4.4.2.3.2. Steps for a multiple instrument portfolio

Extending the methodology to handle realistic, multiple-instrument portfolios requires

some additional work performed in three of the steps outlines above.

- Step 1

  Many more market factors are likely in multiple-instrument portfolios, for example the interest rates for longer maturities bonds, exchange rates, volatilities and correlations. These factors must be identified and pricing formulas expressing the instruments values in terms of the market factors must be obtained. Options may be handled either by treating the option volatility as an additional market factor that requires simulation, or treating the volatilities as constants and disregarding the fact that they change randomly over time (Linsmeier & Pearson, 1996:8).

- Step 2

  In this step the joint distribution of possible changes in the values of all the market factors must be determined. This joint distribution must include the option volatilities, if they are variable.

- Step 3

  In order to accurately reflect the correlations and volatilities of market rates and prices it is necessarily to compute and sum mark to market profits and losses on every instrument for each day, before they are ordered from highest profit to lowest loss in Step 4. Steps 4 and 5 are the same for either a one-position or a multiple-position VaR (Linsmeier & Pearson, 1996:8).

4.4.2.3.3. Some issues on Monte Carlo

- Random numbers

  Monte Carlo simulation depends on drawing from random numbers from a random number generator. However, these random numbers are often not random at all. Pseudo-random-numbers generated from an algorithm employing a deterministic rule (i.e., a rule that does has no random elements). These numbers take some initial value, a "seed" value and then generate a series of numbers that *appear* random (McCreary, 2001:2). It is essential that the number generator is robustly designed in order to pass the standard test for randomness and

among these especially the test for independence (McCreary, 2001:6).

If a random number generator is insufficiently robust the random numbers it produces will not have the properties it is assumed to have (e.g., they may not be independent of each other). Results derived from these values could be compromised. It is therefore critical to use a good random number generator (Dowd, 1998:113).

Another problem with random number generators is that they will always generate the *same* sequence of numbers from the *same* initial seed number. Eventually, the seed number will recur and the sequence of random numbers will repeat itself. All random number generators cycle after a certain number of drawings and, usually, at issue is the length of time they take to cycle: "good" random generators will cycle after billions of draws, "bad" ones will cycle after only a few thousand cycles. If the cycle is too short relative to the number of drawings, the extra accuracy from taking many drawings is spurious. Results obtained from generating more random numbers does not result in an increase in accuracy. It is therefore important to use a random number generator with as long a cycle as possible (Dowd, 1998:112 and McCreary, 2001:3).

The Monte Carlo procedure may be modelled in Microsoft Excel™ . The procedure for generating correlated, random number sequences[32] uses the rand() function in Excel, which has too short a time-span before it begins to repeat its cycle. An acceptable random number generator may be generated using:

$$\text{Pseudo random number} = \sum_{i=1}^{12} rand(\,)_i - 6 \qquad \textbf{4-14}$$

(Wilmot, 1998:36).

- Ensuring a positive semi definite variance-covariance matrix

[32] The maintenance of volatilities and correlations is critical to this procedure and accomplished via the Cholesky decomposition (Hubbert, 2004:3). A detailed mathematical derivation and description of the Cholesky decomposition is outside scope of this dissertation.

The Cholesky decomposition (Hubbert, 2004:3) requires a stable variance covariance matrix on which to base its correlated random numbers. The accuracy and stability of the volatilities and correlations used in the matrix is critical, but so also is the requirement that the variance covariance is positive semi-definite[33]. If this condition is not met the variance covariance matrix cannot be used and the scenario generation process cannot take place. This condition will only be satisfied if two other conditions hold:

- the number of observations from which the variance covariance matrix is estimated must be at least as great as the number of dimensions in the matrix itself and
- none of the instruments in the series are perfectly correlated (correlation of 1) with another instrument in the series (Dowd, 1998:138).

As the number of observations in the time series increases relative to the number of constituents held, so does the accuracy of the model. The number of random drawings that is produced will affect the accuracy of the model. The more drawings being produced the higher the accuracy of the model. Longer computation times are also associated with more drawings.

- Model risk

Results from Monte Carlo procedures depend critically on the models used to describe the relevant price processes. Incorrect pricing models lead to incorrect simulation results. Choosing relevant models for instruments is fairly simple for plain vanilla instruments where well-established models are available, but for more complex instruments, particularly some exotic derivatives in there are a number of models from which to choose, the calculation becomes more diffi-

[33] A matrix $\mathbf{A} \in \Re^{n \times n}$ is positive semi-definite if $\forall \mathbf{x} \in \Re^n \Rightarrow \mathbf{x}^T \mathbf{A} \mathbf{x} \geq 0$ (Marcus and Mink, 1988:182).

cult. Each of the models used have their own advantages and disadvantages, giving rise to model risk. The choice of correct model is therefore critical.

For equity positions a Geometric Brownian Motion model may be used (Hull, 1997:213). The model assumes that stock prices at time t, S_t, are governed by the process:

$$\frac{dS_t}{S_t} = \mu \cdot dt + \sigma \cdot dW_t \qquad \textbf{4-15}$$

where μ is the growth of the stock price, S_t

t is the time unit,

σ is the stock volatility and

$dW_t = \varepsilon \cdot \sqrt{\Delta t}$ where the disturbance term, ε, is identically and independently distributed (JP Morgan, 1996:32) and

$\sqrt{\Delta t}$ reflects the "square root of time" statistical rule for the scaling of volatility.

Changes in the stock price are driven by random standardised normal variable W_t. The volatility of the stock price also decreases as the length of the time interval, Δt, gets smaller, a feature which eliminates large jumps in the stock price and characterises the process as Brownian (Dowd, 1998:114). In addition, the change in the stock price is allowed to have non-zero drift term that captures expected changes in the stock price.

For fixed income instruments, modelling the prices is by contrast much more difficult than modelling equity prices. Traditionally, duration and convexity are used, but this method ignores the modulation of the bond price focusing instead on the price change due to duration and convexity (Fabozi, 2000:255) as shown in Equation 4-16 below:

$$\Delta p / p \approx -D_m \cdot \Delta y + \frac{1}{2} C(\Delta y)^2 \qquad \textbf{4-16}$$

For this approach, the modified duration (D_m), and convexity (C) parameters must be calculated (Dowd, 1998:115). The duration and convexity are then used in the Equation 4-16 and price (p) changes (Δp) are measured with corresponding changes in the yield (Δy) (Fabozi, 2000:268). VaR then follows fairly easily given some assumed price distribution function for the bond yield process.

Problems with this technique include the assumption of a flat yield curve. This model does not, therefore, take account of yield curve shape changes. Recent work by van Vuuren *et al.,* (2005), has shown promising developments in this field. Another drawback of this approach is that it is not suitable for more complex or exotic instruments.

Because of these problems some alternative, but potentially more difficult, approaches must be sought to measure security prices (Honor, 1998:29). The Hull and White model (Hull and White, 1993:582) or the Cox-Ingersoll-Ross model (Cox *et al.,* 1985:394) may be used for this purpose. The latter is given in Equation 4-17 below:

$$dr_t = k(\mu - r)dt + \sigma\sqrt{r_t \cdot dW_t} \qquad \text{4-17}$$

where:

dr_t is the change in interest rates at time t,

k is a mean-reversion factor, dependent on the data used,

μ is the long run mean,

r is the current level of interest rates,

σ is the volatility of the interest rates and

$dW_t = \varepsilon \cdot \sqrt{\Delta t}$ as in Equation 4-14

The Cox-Ingersoll-Ross model enjoys the advantage that it captures the fact that interest rates revert to long-run means: if r_t is very high, the first term is negative and the interest rate will tend to come down, and vice versa. The model

only allows one factor to drive interest rates, however, and this can create problems if the model is used for pricing purposes.

This weakness can be helped to some extend by using a different model such as the Longstaf-Scwartz (2001:122) model that allows the interest rate to depend on two factors instead of one. Even two factor models are still excessively restrictive for real world pricing purposes. Most industry practitioners therefore use more sophisticated "no arbitrage" models. Heath *et al.*, (1992:78), is also well known for interest rate models developed. These models designed to rule out arbitrage function and are more flexible than other models. The Heath Model (1992:78) is a popular model with risk managers.

4.4.2.3.4. Advantages of the Monte Carlo method

This method is extremely powerful and flexible, and can handle almost any position. There are no problems with non-linearity and non-normality and this method is ideal for complex and exotic positions (Dowd, 1998:133).

4.4.2.3.5. Disadvantages of the Monte Carlo method

The Monte Carlo method is unintuitive, opaque and hard to explain. It is highly computing- (and hence time-) intensive, but can be speeded up by using grid or delta-gamma approximations, variance-reducing or quasi-random-number techniques, and it requires considerable human and financial investments (Dowd 1998:133).

The next section presents a literature survey of current VaR topics, which are important to the financial industry as a whole. In addition, specific articles which address the VaR problem from a hedge fund point of view, are reviewed.

4.4.3. VaR literature survey

Allen (1994:77) compared the historical simulation VaR technique to the normal approach, using various and foreign exchange portfolios and found that the historical simulation method estimated VaR better than the normal method. Beder (1995:14) approached his study of VaR by applying eight common methodologies to three

hypothetical portfolios in order to estimate VaR. These results varied from Allen's (1994:77) results. The results indicated that VaR is mainly dependent on parameters, data, assumptions, and methodology.

Crnkovic-Drachman (1995:81) compared normal and historical simulation approaches to VaR for stock index portfolios and the result was a generally improved approach compared to normal VaR. Butler & Schachter (1996:1) used several real trading positions to measure VaR at a 95% confidence level by using normal, bootstrapped and the historical-kernel approach. The major finding of this study was that VaR estimates were closely correlated, although differences between VaR estimates are not necessarily negligible. The normal model generated more stable and generally lower estimated standard errors than the other two methods.

Danielsson & De Vries (1997:18) compared RiskMetrics, the historical simulation and extreme value approaches. The RiskMetrics approach performed well for low-confidence-level VaR, but increasingly overpredicted tails, and overpredicted more as the tail data become more extreme. The extreme value approach performed well overall, and particularly well as the tails become more extreme. (Holton, 2003:318)

Delta-gamma approaches, which led to significantly better VaR for portfolios containing options, were examined by Estrella *et al.*, (1994:34) and Fallon (1996:144). The variance-covariance and historical simulation approaches were explored by Estrella *et al.*, (1994:37). Volatility assumptions and the length of the period used for historical analysis were altered and the effect on the VaR calculated. Estrella *et al.*, (1994:38) found that some historical scenario approaches perform better than variance-covariance approaches and that the choice of confidence interval has a substantial effect on the overall VaR calculated. VaR estimates at the 99% confidence level were in general, too low, regardless of the method used (Jorion, 2004:292). Jackson, *et al.*, (1997:74) compared VaRs on different portfolios (comprising interest rate and foreign exchange options) using the historical simulation method. They found historical simulation techniques gave superior VaR values over normal approaches – particularly in the tail regions where the normal method failed and constantly overestimated VaR.

The number of research articles that VaR has attracted is vast and ongoing. A comprehensive literature survey lies outside the scope of this dissertation, but the inter-

ested reader may consult works such as Dowd, (1998), and Jorion, (2004) which provide definitive overviews of the subject.

4.4.4. VaR and hedge funds

Hedge fund assets under management have been growing since 1995 for several reasons. One of the reasons driving growth is the attractive risk-adjusted performance achieved by hedge funds as well as their ability to protect capital in negative equity markets. However, the nature of the industry makes hedge fund investing difficult.

Given the wide variety of hedge fund strategies, hedge fund managers and investors are exposed to many kinds of risk including market risk, interest rate risk, liquidity risk, credit risk, counterparty risk and fraud risk. Some of the risks incurred by hedge funds have been explained in Chapters 3 and 4. The main difference between risk management in long only portfolios and hedge funds is that hedge funds can take short positions and often adopt more complex strategies.

Counterparty risk[34], is a risk that is not incorporated into the traditional VaR and liquidity figures that this chapter explored. Hedge funds that hold short positions must borrow script from counterparties. The counterparty can call back the scrip at any time forcing the hedge fund manager to liquidate that position and return the script in due time. This has implications for risk management of hedge funds and further research could be carried out to incorporate this into known measures such as VaR. The role of liquidity risk in the measurement of VaR is explored in the next section.

4.5. Liquidity Risk

4.5.1. Introduction

Value at Risk (VaR) has enjoyed a phenomenal increase in popularity since its formulation in the late 80's and is now a widely used risk metric for measuring market risk. Whilst considerable attention has been given to the measurement of volatility and cor-

[34] The risk to each party of a contract that the counterparty will not live up to their contractual obligations.

relation as well as the incorporation of these values into portfolio VaR, liquidity risk still remains severely under-examined (Bouchaudy & Pottersy, 1999:2). It is included in standard VaR calculations only in an *ad hoc* fashion, namely by increasing the time horizon over which VaR is calculated to account for the time taken to liquidate a large position (JP Morgan, 1996:12–15 & Schachter, 2003:S3). Not only does this technique not distinguish between exogenous and endogenous liquidity, but it employs the "square root of time" rule, in which it is assumed that no autocorrelation exists between rates of return from one measurement period to another. This assumption of a lack of autocorrelation allows for simple arithmetic summation of individual variances to produce the overall "period under investigation" variance. Thus, for example:

$$\text{variance}_{10\,\text{day}} = 10 \cdot \text{variance}_{1\,\text{day}},$$

and, as a direct consequence this leads to the statistical conclusion that:

$$\sigma_{10\,\text{day}} = \sqrt{10} \cdot \sigma_{1\,\text{day}}. \qquad \textbf{4-18}$$

4.5.1.1. Definitions

- **Exogenous liquidity risk** is the result of market characteristics; it is common to all market players and unaffected by the actions of any one participant (Bangia *et al.,* 1998:1 - 2). In response to a market shock (and the resultant loss of predictability), a vicious cycle with a corresponding loss of liquidity is initiated (Cosandey, 2001:115). The perceived need to hold larger prudential reserves in situations of greater uncertainty along with reduced liquidity and leverage may not break the self-reinforcing dynamics of market dislocations. Exogenous liquidity can be affected by the joint action of all or almost all market participants as occurred in several markets in the summer of 1998 (Lowenstein, 2001: 46). The market for liquid securities, such as G7 currencies, is typically characterized by heavy trading volumes, stable and small bid-ask spreads, stable and high levels of quote depth (IMF, 2000:78-102). Liquidity costs may be negligible for such positions when marking to market provides a proper liquidation value. In contrast, markets in emerging currencies or thinly traded junk bonds are illiquid and are characterized by high volatilities of spread, quote depth and trading volume (Alexander 2001:125).

- **Endogenous liquidity risk**, in contrast, is specific to the position in the market and varies across market participants (Bangia *et al.*, 1998:2 & BIS, 2004:1). The exposure of any one participant is affected by the actions of that participant. It is mainly driven by the size of the position: the larger the size, the greater the endogenous illiquidity. If the market order to buy/sell is smaller than the volume available in the market at the quote, then the order transacts at the quote. In this case the market impact cost, defined as the cost of immediate execution, will be half of the bid-ask spread (Jarrow and Subramanian, 1997:170 and 2001:447). If the size of the order exceeds the quote depth, the cost of market impact will be higher than the half-spread. The difference between the total market impact and half-spread is called the incremental market cost, and constitutes the endogenous liquidity component.

4.5.1.2. Literature study

Recent work has begun to incorporate vanishing liquidity in times of crisis. Le Saout (2001:1) provides a good review of liquidity risk in VaR models and gives a comprehensive overview of recent research in the field.

Lawrence and Robinson (1998:64) were among the first to identify and establish that conventional VaR models often exclude asset liquidity risk. They argued that the best way to capture liquidity issues within the VaR framework would be to match the VaR time horizon with the time investors believed it could take to exit or liquidate the portfolio. They established that the liquidation of a portfolio over several trading days generated additional liquidity costs.

Diebold & Lopez (1996:427) showed that scaling volatilities by the square root of time is only applicable if log changes of price returns are i.i.d. (independently and identically distributed) and, in addition, normally distributed. They noted that high frequency financial asset returns are *not* i.i.d. and that, even if they are conditional mean independent they are definitely not mean-variance independent (see also Bollerslev *et al.*, (1992:5) and Diebold *et al.*, (1996:1) for evidence of strong volatility persistence in financial asset returns). Diebold *et al.*, (1996:1) showed that scaling by the square root of time magnifies volatility fluctuations, i.e. scaling results in large condi-

tional variance fluctuations of long horizon returns, when in fact the opposite is true. Care must therefore be taken when employing this rule.

Jarrow and Subramanian (1997:170 and 2001:447) considered optimal liquidation of an investment over a fixed horizon. They characterised the costs and benefits of block sales versus slow liquidation and they proposed an endogenous liquidity adjustment to the standard VaR measure. The model requires three quantities which increase the loss level – namely a liquidity discount, the volatility of the liquidity discount and the volatility of the time horizon to liquidation. The authors themselves acknowledge that traders or firms must collect time series data on the shares traded, prices received and time to execution in order to estimate these quantities. Whilst this model is robust and fairly easy to implement, estimating these quantities is by no means trivial. Indeed, some may only be determined empirically with the accompanying introduction of significant bias.

Fernandez (1999:1) examined liquidity risk in the aftermath of the 1998 LTCM liquidity crisis. He argued that:

"...financial markets are undergoing rapid structural change, which may be contributing to liquidity risk. These changes along with rising homogeneity of market participants' behaviour are increasing concentration and "herding behaviour" and eliminating "friction" which may prove disadvantageous in a market correction" (Fernandez, 1999:1).

Fernandez (1999:1) concluded that no single measure captured the various aspects of liquidity in financial markets, but rather a composite of measures, incorporating quantitative and qualitative factors. His treatment of the problem, however sound, does not address the mathematical issues underlying this complex problem.

Bangia *et al.*, (1999:68) explored exogenous liquidity risk. They treated the liquidity risk and market risk jointly and made the assumption that in adverse market environments extreme events in returns and extreme events in spreads occur concurrently. They noted that while the correlation between mid-price movements and spreads was not perfect, it was strong enough during extreme market conditions to encourage the treatment of extreme movements in market and liquidity risk simultaneously. They

incorporated both a 99th percentile movement in the underlying and a 99th percentile movement in the spread (McNeil, 1996:1 & Mulvey: 2003:4).

Almgren & Chriss (1999:58) examined endogenous liquidity risk by considering the problem of portfolio liquidation. They aimed to minimise a combination of volatility risk and transaction costs arising from permanent and temporary market impact. From a simple linear cost model, they built an efficient frontier in the space of time-dependent probability. They considered the risk-reward trade-off both from the point of view of classic mean-variance optimisation and the standpoint of VaR (BIS, 1988:2). Their analysis led to general insights into optimal portfolio trading, and to several applications including a definition of liquidity-adjusted Value at Risk.

The problem of ignoring liquidity risk is amplified when considering hedge funds. Hedge fund manager styles were addressed by L'Habitant (2000:3, 2001:17) who noted that there was a need to introduce new quantitative tools to assist investors assessing the investment characteristics and the risks of hedge funds. Using only NAV's from a hedge fund, L'Habitant (2001:17) proposed a methodology to identify strategic and tactical hedge fund asset allocations and compare their performance against an ad-hoc benchmark. The method on which he relied was a returns-based style analysis introduced by Sharpe (1988:63). L'Habitant (2001:18) also notes that:

> "...there are numerous directions for future research. In particular, the framework presented in this paper does not incorporate all the risk components to which a hedge fund investor is exposed. For instance, we have completely omitted credit and liquidity risks, which are also essential parts of the full risk picture of a hedge fund." (L'Habitant, 2001:19).

4.5.2. Liquidity VaR

Whilst many liquidity-adjusted risk models exist, Jarrow and Subramanian's work (1997:170 and 2001:447) – henceforth "J&S" – is increasing in importance as the endogenous liquidity model of choice (see, for example Çetin *et al.*, 2004:1, Umut *et al*, 2004:1 and Erwan, 2002:1). J&S's work focussed on *endogenous* liquidity risk or that risk which arises from trading large positions under normal trading conditions for *single share* positions. No attempt has been made by subsequent authors to expand the J&S model to embrace *portfolios* of shares. Diminished liquidity exerts maximal im-

pact on a position's unwind period, but the volatility of such shares is also affected and, moreover, correlations between illiquid securities is significantly altered. The effect of illiquidity on portfolio VaR is presented in this section.

4.5.2.1. Overview of the J&S model

The J&S model will be used to determine the VaR of individual shares which suffer restricted liquidity. Amendments will then be made to the original J&S model to incorporate these liquidity-adjusted VaRs into a portfolio liquidity adjusted value at risk (La-VaR) using a combination of portfolio theory (Archer, 2005:1) and the variance covariance VaR technique (Fischer Investments, 2001b:1) in the next Section. This Section summarises the essential requirements for the J&S *individual instrument* La-VaR model.

Parameters that are required as input for the J&S model necessitate the determination of the liquidity discount, the volatility of the liquidity discount and the volatility of the time horizon to liquidation. J&S concluded that the single instrument La-VaR was given by:

$$\text{La - VaR} = \rho \cdot S \cdot \left| \mu \cdot \{E(\Delta S) + E(\log[c(S)])\} - CI \cdot \left[\sigma \cdot \sqrt{E(\Delta S)} + |\mu| \cdot \text{vol}(\Delta S) + \text{vol}(\log[c(S)]) \right] \right| \quad \textbf{4-19}$$

where:

ρ is the quantity of equity purchased (or short-sold),

S is the price of the equity (hence $\rho \cdot S$ is the nominal amount invested (i.e. quantity × price),

μ is the average period return,

$E(\Delta S)$ is the expected value of the time horizon to liquidation,

CI is the confidence interval,

σ is the standard equity-return volatility,

$\text{vol}(\Delta S)$ is the volatility of the time horizon to liquidation and

$\text{vol}(\log[c(S)])$ is the volatility of the liquidity discount.

Note that the J&S La-VaR has essentially the same basic structure as the standard variance-covariance method of calculating VaR. The variance-covariance VaR is given by (JP Morgan, 1996:36):

$$\text{VaR}_{\text{VCV}} = N \cdot \left(\mu \cdot T - CI \cdot \sigma_{\text{VCV}} \cdot \sqrt{T}\right), \qquad \textbf{4-20}$$

where

N is the nominal amount invested,

μ is the average period return,

T is the time horizon to liquidation,

σ_{VCV} is the standard variance-covariance portfolio volatility and

CI is the confidence interval.

Comparing the J&S (Equation 4-19) with the standard variance covariance VaR model (Equation 4-20) gives:

$$\begin{aligned} \text{La - VaR} &= \underbrace{\rho \cdot S} \cdot \left| \mu \cdot \underbrace{\{E(\Delta S) + E(\log[c(S)])\}}_{T} - CI \cdot \left[\underbrace{\sigma \cdot \sqrt{E(\Delta S)} + |\mu| \cdot \text{vol}(\Delta S) + \text{vol}(\log[c(S)])}_{\sigma_{\text{VCV}} \cdot \sqrt{T}} \right] \right| \\ \text{VaR}_{\text{VCV}} &= N \cdot \left(\mu \cdot \qquad T \qquad - CI \cdot \qquad \sigma_{\text{VCV}} \cdot \sqrt{T} \right) \end{aligned}$$

It is clear that $N = \rho \cdot S$ and ***by analogy*** it may be concluded that $T \equiv E(\Delta S) + E(\log[c(S)])$[35]. In addition, $\sigma_{\text{VCV}} \cdot \sqrt{T}$ (or the liquidity-adjusted volatility) is ***analogous*** to the final term or:

$$\sigma_{\text{VCV}} \cdot \sqrt{T} \equiv \sigma \cdot \sqrt{E(\Delta S)} + |\mu| \cdot \text{vol}(\Delta S) + \text{vol}(\log[c(S)]). \qquad \textbf{4-21}$$

Equation 4-21 will be used in the next section.

---

[35] The symbol ≡ means "is equivalent to" and in this context refers to the fact that *T is equivalent to* $E(\Delta S) + E(\log[c(S)])$. It does *not* mean that *T equals* $E(\Delta S) + E(\log[c(S)])$.

For any given instrument, the parameters and inputs required to measure its La-VaR, using Equation 4-19, may be calculated or estimated. Financial institutions or funds trade portfolios comprising *many* instruments, each with its own liquidity adjusted VaR calculated using Equation 4-20. These individual La-VaRs must be combined to give an overall portfolio La-VaR and this is covered in the next section.

4.5.3. Portfolio Liquidity-Adjusted VAR

Instruments in any given portfolio may have identical unwind periods, but this will be the exception rather than the rule. In most portfolios, *different* timescales will be required to liquidate constituent equity positions. This Section compares four different ways of calculating portfolio La-VaR by successive relaxation of assumptions (and hence successive increasing of refinements) from one model to the next. A detailed practical example follows which describes current, widely-practised methodology, the J&S model and an adapted J&S model.

4.5.3.1. Methodology and Assumptions

A portfolio comprising two equities with unequal unwind periods was constructed and the portfolio VaR[36] calculated using four different methods, described below.

For a simple, derivative-free portfolio the historical method (Section 4.4.2.1) produces reliable, robust VaR measures without invoking assumptions about return volatilities, correlations or unwind periods. To gain assurance of this reliability, the historical VaR values were back-tested and compared to the observed profit and loss record using a 99% confidence interval. These VaR values were then used as a benchmark against which to test other models.

The second ("standard") model used employs the standard variance-covariance technique for estimating daily VaR. To obtain La-VaR, the standard approach involves a simple scaling of daily VaR by the square root of the average unwind period (in this case $\sqrt{(1+10)/2}$ or a factor of 2.35).

[36] A long-long and a long short equity portfolio were used for completeness.

The third model improves on the second by incorporating the J&S endogenous liquidity adjustments directly into the VaR calculation at instrument level. Portfolio VaR using these individual La-VaRs is obtained from portfolio theory (Archer, 2005:3):

$$\text{La}-\text{VaR}_{\text{PF}} = \sqrt{(w_A \cdot \text{La}-\text{VaR}_{\text{A}})^2 + (w_B \cdot \text{La}-\text{VaR}_{\text{B}})^2 + 2\cdot(w_A \cdot \text{La}-\text{VaR}_{\text{A}})\cdot(w_B \cdot \text{La}-\text{VaR}_{\text{B}})\cdot\rho_{AB}} \quad \textbf{4-22}$$

or, in matrix notation:

$$\text{La}\text{-}\text{VaR}_{\text{PF}} = \sqrt{(w_A \cdot \text{La}-\text{VaR}_{\text{A}} \quad w_B \cdot \text{La}-\text{VaR}_{\text{B}})\cdot\begin{pmatrix} 1 & \rho_{AB} \\ \rho_{BA} & 1 \end{pmatrix}_{\text{1-day/1-day}}\cdot\begin{pmatrix} w_A \cdot \text{La}-\text{VaR}_{\text{A}} \\ w_B \cdot \text{La}-\text{VaR}_{\text{B}} \end{pmatrix}} \quad \textbf{4-23}$$

where w_A and w_B are the weights in the respective equities and

ρ_{AB} is the correlation calculated between the 1-day returns for both equities.

The fourth and final method again uses the individual instrument J&S La-VaRs as above, but instead uses the correlations between the 1-day and 10-day returns (recall that the unwind periods are 1 day and 10 days respectively), as opposed to the correlations between the 1-day and 1-day returns. In this way actual unwind period (liquidity) correlations are also embedded within the VaR calculation. A summary of the four procedures to be conducted and compared is shown below in Figure 4.10.

First *daily* returns were generated for two equities, A and B, with the assumption that equity prices were governed by standard Geometric Brownian Motion[37] (Hull, 1997:223). The correlation between A and B's *daily* returns is a chosen parameter that could be varied[38] and 10 000 scenarios were generated. This amount of scenarios were used because the computation time required in excel for these calculations became particularly onerous for simulations in excess of 10 000. These values (daily volatilities, average daily returns, correlation between daily returns) result in two, random,

---

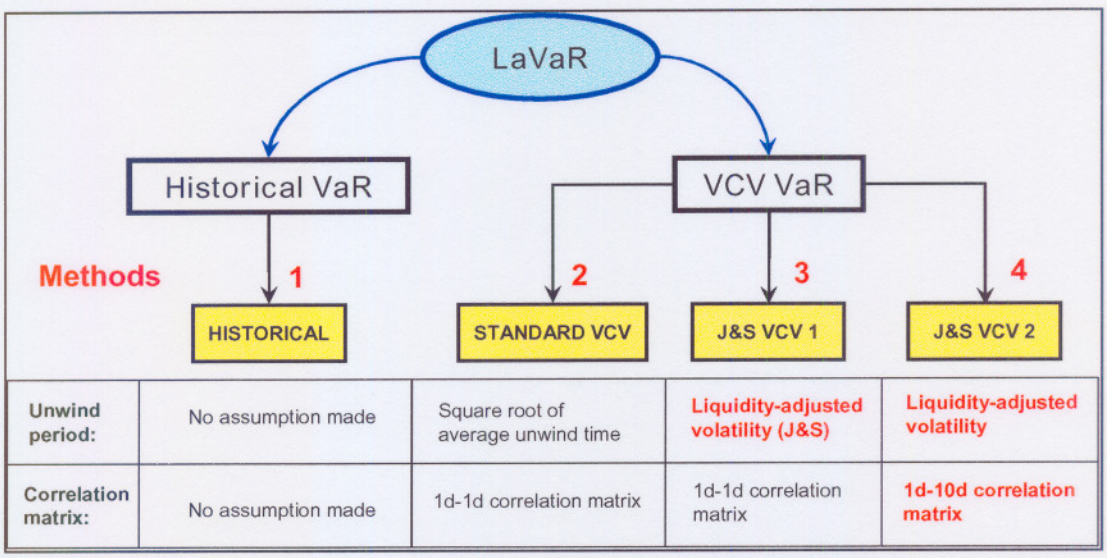
[37] That is $dP/P = \mu \cdot dT + \sigma \cdot \varepsilon \cdot \sqrt{dT}$ where P is the equity price, μ is the average daily return, σ is the daily volatility, T is measured in days and ε is a random number between 0 and 1 drawn from a standard cumulative normal distribution.

[38] This method uses the standard Cholesky Decomposition (Hull, 1997:413) method of generating correlated, random series.

correlated, daily-return series for A and B. Other variables that were simulated (including amount invested in A and B, individual mean return volatilities, average daily returns, and so on), but changing these added nothing to the current understanding of the problem.

For example, simulations in which the volatility levels *only* were adjusted did not materially affect the results other than scaling them. Such parameters were therefore held constant; the La-VaR was simulated by varying only the correlation. In addition, the liquidity discount, the volatility of the liquidity discount and the volatility of the time horizon to liquidation were estimated from market data and held constant for this study.

Figure 4-10 Comparison of La-VaR techniques. The red text indicates assumption relaxations.



These results were also tested with more than two equities, but for explanatory purposes only two equities were used here. The J&S model was constructed with the parameters as indicated in Table 4-2 and Table 4-3, unless otherwise specified.

Table 4-2 Long-only portfolio parameters.

Long- only portfolio	EQUITY A	EQUITY B
Amount invested	R1	R1
Daily return volatility	1.57%	1.57%
Average daily return	0%	0%
Unwind period	10d	1d
Return correlation (A-B)	Varies between -1 and +1	

Table 4-3 Long short portfolio parameters.

Long- short portfolio	EQUITY A	EQUITY B
Amount invested	-R1	R1
Daily return volatility	1.57%	1.57%
Average daily return	0%	0%
Unwind period	10d	1d
Return correlation (A-B)	Varies between -1 and +1	

The four approaches used to estimate the La-VaR for each of the above portfolios will now be discussed in detail.

4.5.3.2. Historical portfolio VaR

The portfolio profit and loss (P/L) data was first determined. Using the return generation method as described above, 5 000 possible return scenarios were generated. Recall that the returns generated above were *daily* returns. A 10-day return for Equity A is required since there will be portfolio exposure to this equity for 10 full days as the position is unwound. These 10-day returns may be generated by first determining daily equity *prices* from the daily return series (assuming continuous compounding). Daily prices may be calculated from

$$R_{1\,\text{day}} = \ln\left(\frac{P_T}{P_{T-1}}\right), \qquad \textbf{4-24}$$

assuming an arbitrary start price of R1. *10-day returns* for equity A are then calculated using:

$$R_{10\,\text{day}} = \ln\left(\frac{P_T}{P_{T-10}}\right). \qquad \textbf{4-25}$$

These returns are then used to generate portfolio P/L from:

$$R_{\text{PORTFOLIO}} = \left(w_A \cdot R_{A\,(10\text{-day})}\right) + \left(w_B \cdot R_{B\,(1\text{-day})}\right) \qquad \textbf{4-26}$$

where w_A and w_B are the portfolio weights in A and B respectively, in this case, 50% each. These portfolio returns are then ranked, and the 5th percentile found to give the historically-estimated, portfolio VaR. This is a liquidity-adjusted VaR since the addi-

tional time required to liquidate the portfolio assets were taken into account.

4.5.3.3. La-VaR – "Standard" Method

This technique calculates the portfolio VaR using the standard variance-covariance method (Section 4.4.2.2.) and the *average* unwind period of the portfolio constituents (JP Morgan, 1996:47). Portfolio VaR is estimated from Equation 4-20 with $\mu = 0$:

$$\text{VaR}_{\text{VCV}} = N \cdot CI \cdot \sigma_{\text{VCV}} \cdot \sqrt{T} \qquad \textbf{4-27}$$

where the portfolio *daily* volatility is given by:

$$\sigma_{\text{VCV}} = \sqrt{\begin{pmatrix} w_A & w_B \end{pmatrix} \cdot \begin{pmatrix} \sigma_A^2 & \sigma_A \cdot \sigma_B \cdot \rho_{AB} \\ \sigma_B \cdot \sigma_A \cdot \rho_{BA} & \sigma_B^2 \end{pmatrix} \cdot \begin{pmatrix} w_A \\ w_B \end{pmatrix}} \qquad \textbf{4-28}$$

or, equivalently

$$\sigma_{\text{VCV}} = \sqrt{\begin{pmatrix} w_A \cdot \sigma_A & w_B \cdot \sigma_B \end{pmatrix} \cdot \begin{pmatrix} 1 & \rho_{AB} \\ \rho_{BA} & 1 \end{pmatrix}_{\text{1-day/1-day}} \cdot \begin{pmatrix} w_A \cdot \sigma_A \\ w_B \cdot \sigma_B \end{pmatrix}} \qquad \textbf{4-29}$$

giving:

$$\text{La - VaR}_{\text{VCV}} = N \cdot CI \cdot \sqrt{\begin{pmatrix} w_A \cdot \sigma_A \cdot \sqrt{T} & w_B \cdot \sigma_B \cdot \sqrt{T} \end{pmatrix} \cdot \begin{pmatrix} 1 & \rho_{AB} \\ \rho_{BA} & 1 \end{pmatrix}_{\text{1-day/1-day}} \cdot \begin{pmatrix} w_A \cdot \sigma_A \cdot \sqrt{T} \\ w_B \cdot \sigma_B \cdot \sqrt{T} \end{pmatrix}} \qquad \textbf{4-30}$$

where the symbols have their usual definitions[39]. It is important to note that all volatilities and correlations are measured using *daily* returns. The unwind period (taken as the average of the constituent unwind periods, (JP Morgan, 1996:52)) in this case, is $(1+10)/2 = 5.5$ days. These quantities combine into the La-VaR equation above.

---

[39] Equation 4.30 has been formulated in this unconventional way to extract and thus demonstrate the use of the 1-day/1-day return correlations employed. This is important for the changes that will be made to the methodology in following Sections.

4.5.3.4. La-VaR – Using J&S liquidity adjustments

This technique employs the J&S model to calculate the La-VaR's for the individual equities and then combines these in the standard way (Archer, 2005:1) to give portfolio VaR.

Applying the J&S model to each of the equity returns and employing the commonly-used assumption that average period returns are 0% (JP Morgan, 1996:59), Equation 4-19 becomes (for either share A *or* B):

$$\text{La - VaR} = \rho \cdot S \cdot CI \cdot \underbrace{\left|\sigma \cdot \sqrt{E(\Delta S)} + |\mu| \cdot \text{vol}(\Delta S) + \text{vol}(\log c(S))\right|}_{\tilde{\sigma} \cdot \sqrt{T}}, \qquad \text{4-31}$$

with the term in the modular brackets equivalent to a "liquidity adjusted volatility" since it represents a combination of the volatility and the unwind period element: $\tilde{\sigma} \cdot \sqrt{T}$ (Section 4.5.2.1). The portfolio La-VaR here is calculated using Equation 4-30 with individual La-VaRs calculated using Equation 4-19 above and using a 1-day/1-day correlation matrix. Note that the $\tilde{\sigma} \cdot \sqrt{T}$ terms are the J&S liquidity-adjusted analogues, using Equation 4-21.

4.5.3.5. La-VaR – Using J&S liquidity adjustments and an adjusted correlation matrix

In addition to the technique used in Section 4.5.3.4, the 1-day/10-day correlation matrix was then used instead of the 1-day/1-day correlation matrix. This new technique captures the true, embedded correlation structure of the portfolio. Since equity A requires a full 10 days to unwind and equity B only a single day, it is understandable that the relevant equity returns are the 10-day (A) and 1-day (B) returns – *not* scaled versions of 1-day returns.

The La-VaRs for the two equities may be combined into a portfolio La-VaR thus:

$$\text{La - VaR}_{\text{VCV}} \equiv \sqrt{\left(w_A \cdot \text{La} - \text{VaR}_{\text{A}} \quad w_B \cdot \text{La} - \text{VaR}_{\text{B}}\right) \cdot \begin{pmatrix} 1 & \rho_{AB} \\ \rho_{BA} & 1 \end{pmatrix}_{\text{10-day/1-day}} \cdot \begin{pmatrix} w_A \cdot \text{La} - \text{VaR}_{\text{A}} \\ w_B \cdot \text{La} - \text{VaR}_{\text{B}} \end{pmatrix}} \qquad \text{4-32}$$

where the correlation matrix has been adjusted in such a way that 10-day/1-day returns have been used instead of 1-day/1-day returns. In this way, the use of the $\sqrt{T}$ - rule is entirely eliminated, no assumptions need to be made about autocorrelations between daily returns and the "true" embedded correlation structure is incorporated into the calculation of the overall La-VaR.

The results are presented in the next section.

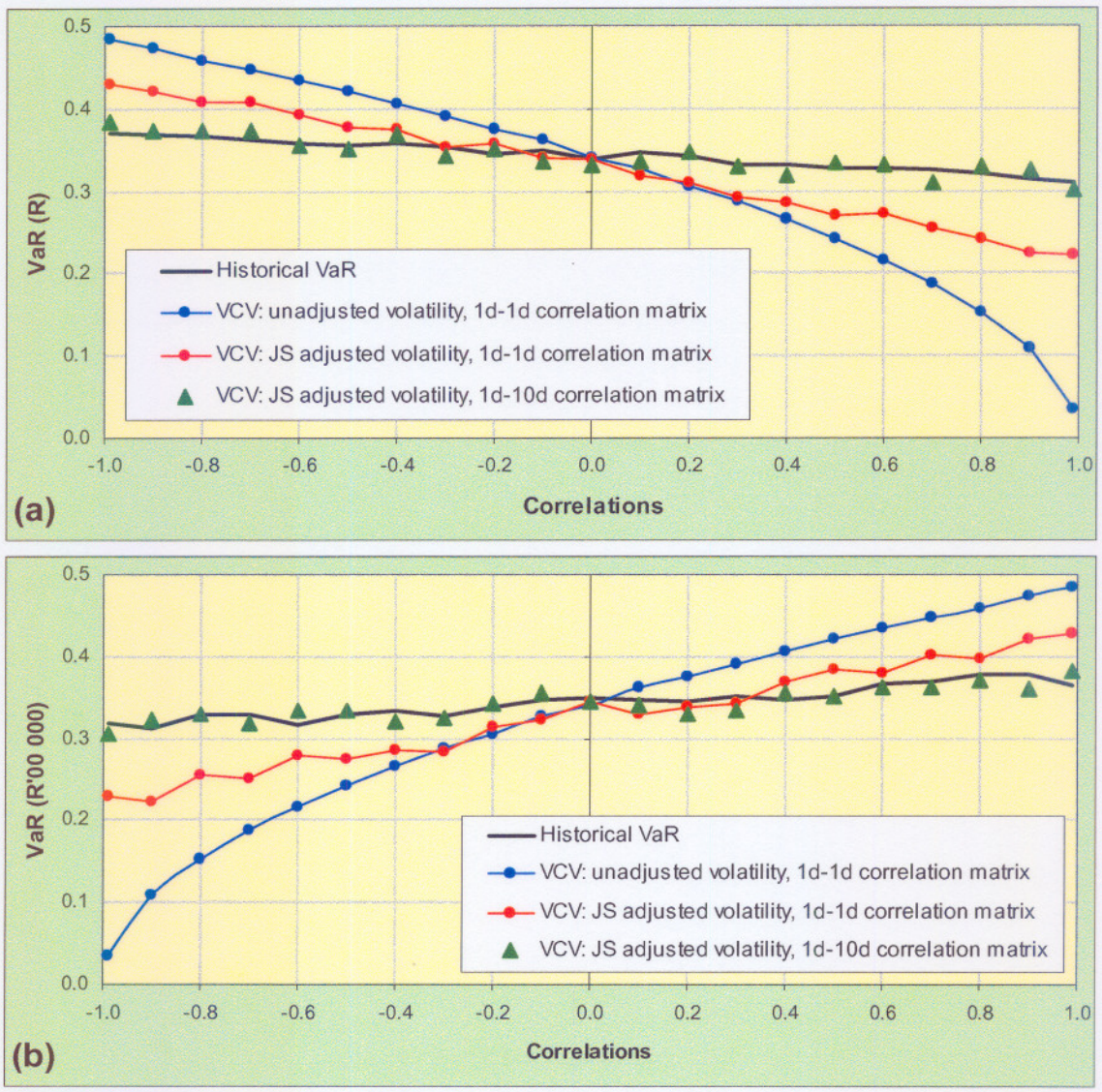
4.5.4. Results

The results obtained from these four methods are shown in Figure 4.11a (long-only portfolio) and Figure 4.11b. (long short portfolio) below.

Recall that the relevant parameters were as shown in Table 4-2 for Figure 4.11a and Table 4-3 for Figure 4.11b with the 1-day/1-day return correlation varying from –1 to +1 in small incremental steps. The 1-day/1-day return correlation (as input to the model used) was varied and then the 10-day/1-day correlation output was *measured.* This was undertaken, rather than varying the other parameters (volatility, daily return and amounts invested) as it is was found that changing the other parameters reveals nothing new and results only in a scaling of the results, whilst the correlation is the key to the solution of calculating portfolio La-VaR.

The historical La-VaR in Figure 4.11a increases from left to right, as expected, indicating that as equity returns become more correlated, La-VaR increases. The more correlated they become the more risky portfolio returns become. The standard VCV VaR method (Method 2) which makes no adjustment for liquidity risk and simply scales the VaR by the square root of the average unwind period, shows the same trend (increasing from left to right), but on a hugely magnified scale. The historical method produces a La-VaR that is some ten times lower at the extremes of correlation than the VCV La-VaR generated using Method 2. This is due entirely to the fact that 10day-1day correlation values are of a much smaller magnitude than 1day-1day correlation values, and this has the effect of constraining the La-VaR measurements to within a smaller range.

Figure 4-11(a) Long only portfolio and (b) long short La-VaR using Method 1 (historical), Method 2 (standard variance-covariance VaR), Method 3 (J&S model) and Method 4 (amended J&S model).



Method 3 makes use of the J&S liquidity adjusted VaRs, but then combines them into a portfolio with the 1-day/1-day correlation matrix. These values are more accurate and the change is not as pronounced as the changes observed using Method 2, but they are still not close to the historical liquidity VaR values. Method 4 employs both the J&S liquidity adjustment *and* an improved correlation matrix for combining the individual La-VaRs into an overall portfolio La-VaR, and gives La-VaR's very close to those determined using the historical method.

This improvement does not necessarily eliminate all statistical assumptions, but does negate the need for the "square root of time" rule which is clearly not an accurate de-

scription of reality.

It was demonstrated that portfolio La-VaR is most accurately determined using the J&S model combined with a "liquidity-adjusted correlation" matrix. With most current research focussing only on individual La-VaR values, there is a clear need to incorporate these values in some way to produce a portfolio La-VaR. Scaling up individual La-VaR's by the square root of the average unwind period produces severe inaccuracies – a result which is not new to the investment community. By taking into account execution lags and liquidity discounts, the individual VaR's are improved, and by incorporating an inherently-scaled correlation matrix, the overall portfolio La-VaR is improved. This is clearly important for long short hedge funds, as many of these funds comprise of pair trades (being long one security and short another) with high return correlations.

4.6. Conclusion

This chapter introduced and discussed hedge fund risk measures. The pros and cons of each were elucidated and a new contribution to the measurement of liquidity risk (an important feature of hedge funds) was suggested and tested.

The next chapter re-examines these measures and demonstrates the application of each in turn to the management of risk in hedge funds.

Chapter 5

Risk Management

5.1. Introduction

The previous chapter discussed important measures used by hedge fund risk managers to gauge the level of risk inherent in these funds. These measures contribute to the overall understanding of the level of risk taken on by hedge fund managers. The application of these measures to the management of risk in hedge funds will be presented in this chapter.

5.2. Hedge fund management process

- Hedge fund management comprises many interacting constituent processes. Each of these embraces some financial risk; often more than one from a list of possibilities (which includes operational risk, liquidity risk, credit risk, market risk, foreign exchange risk, country risk and so on). This chapter focuses specifically on the market (and associated) risk component of risk inherent in hedge funds and ignores, for example, operational risk[40] and credit risk[41]. .

Figure 5-1 below presents a schematic summary of the hedge fund management process. Risks associated with each component process are indicated on the figure. The letters A through L mark the relevant hedge fund management processes; these are described below (OMAM, 2004a).

- A: Previous day traded portfolio positions are reported to risk management, as well as daily P&L and derivative exposures.

---

[40] The management of this risk is a compliance function.

[41] Many long short South African hedge funds may not trade options over the counter. Whilst some hedge funds trade OTC derivatives, counterparty credit risk is assessed by the independent credit risk department along with the legal department.

- B: Risk management collects relevant market price data from data providers such as Reuters or Bloomberg.

- C: Risk management produce the daily risk report. This report includes risk statistics such as daily VaR, liquidity, Beta and other important risk measures and is forwarded to both compliance and fund management for scrutiny. A detailed explanation of the production of the statistics used in this report is discussed in Sections 5.3 to 5.7.

- D: In addition to the daily risk management report, the hedge fund manager also receives other detailed market information which is employed in the decision-making process. This information takes the form of individual company reports, Bloomberg and Reuters data, analyst recommendations and broker reports.

- E: Compliance receives the risk report and monitors it for breaches of mandate. If there has been no breach of mandate no further action is required from compliance. If on the other hand, a mandate breach has occurred, compliance reports this to (1) the legal department, (2) the senior management and (3) the hedge fund manager.

- F: Senior management contacts the hedge fund manager to seek an explanation.

- G: The hedge fund manager explains the breach to senior management.

- H: The hedge fund manager assimilates all the information received described in C and D. This information is used to assist in the trading decision making process.

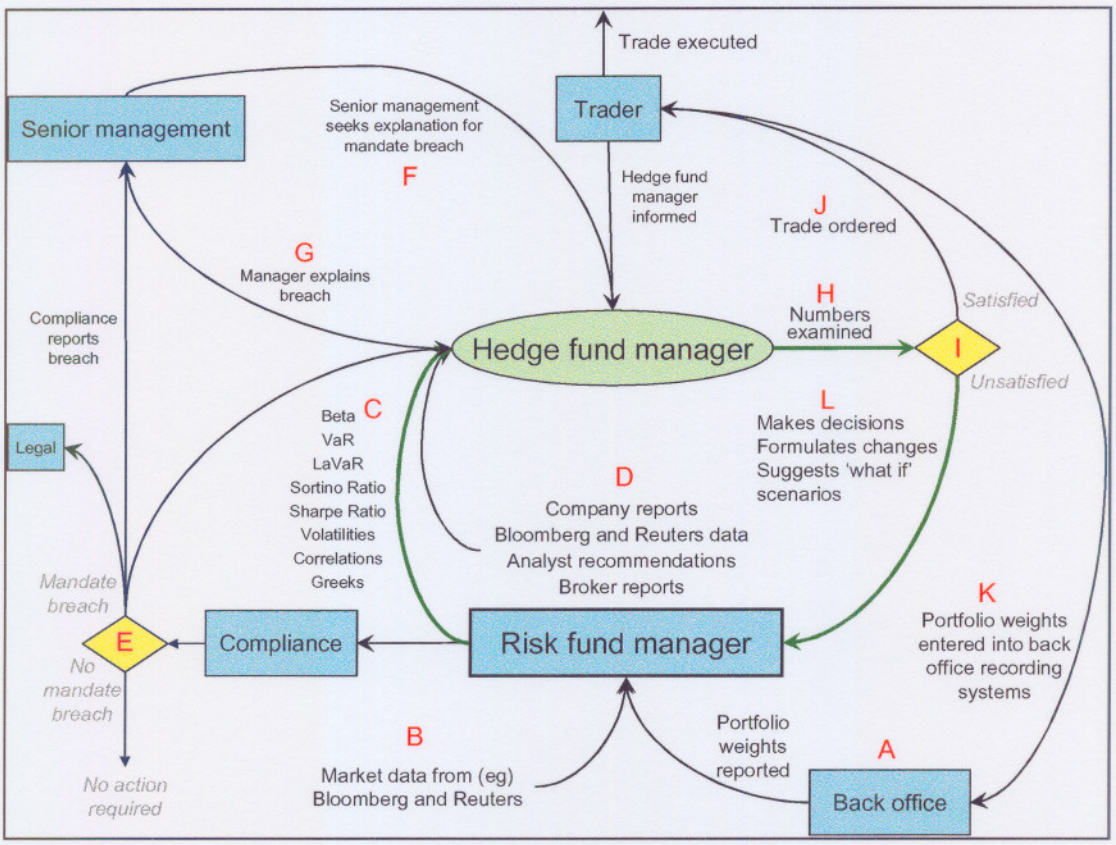
- I: Price levels, company management information, current risk positions, proximity to mandate and prevailing economic conditions are all involved in the hedge fund manager's decision of whether or not to trade and which positions to increase or decrease.

- J: If the hedge fund manager is satisfied with decisions made the order is given to the trader to execute these trades.

- K: The trade order is executed and positions are sent to the back office for recording.

- L: If the hedge fund manager is not satisfied with the changes made to the portfolio further investigation from risk management is requested. The effects of these changes on the portfolio are tested by risk management and these data are fed back to the hedge fund manager, essentially thereby repeating C → H → I → L until the hedge fund manager is satisfied at I and trades are all successfully executed.

Figure 5-1 Schematic summary of the hedge fund management process.



Adapted from de la Torre (2005).

A broad overview of the hedge fund risk management process has been described. Risk measurements which are critical to the processes C → H → I → L are discussed in detail in Sections 5.3 through 5.7.

5.3. Volatility and correlation

Volatility and correlation are widely considered to be the principal measures of risk in finance (Jorion, 2004:287). These are, however, parameters whose values depend on historical observations and are, therefore, not amenable to "management" in the same way that other risk measures (Sections 5.3 through 5.7) are. The accuracy of estimation of these parameters may be improved by methodologies which time-weigh the returns (Section 4.2.1.2) or techniques which time-weigh both returns *and* volatilities (Section 4.2.1.3). Both methods improve the reliability of the volatility and correlation estimates. This improvement leads, in turn, to enhanced accuracy of other risk measures which employ volatility and correlation as constituents (OMAM, 2004b).

Important risk measures that are used to manage hedge fund risk will be discussed in the next sections. In order to examine the management of risk in hedge funds by these risk measures, a mock portfolio comprising 19 equity instruments (weight w_i), cash (weight w_C) and the market was constructed. The market here refers to an overall share index, for example, the JSE, FTSE or Nasdaq. The constituents of the portfolio were random and were allowed to be long or short provided that

$$w_C + \sum_{i=1}^{19} w_i = 1.$$

Volatilities and correlations were simulated and ranged between 10% – 60% and ± 0.99[42] respectively. The mean return of all equities and the market was assumed to be 0%, and only these stocks may be used in the portfolio construction (i.e. changing the portfolio constituents is not permitted). Using this portfolio, risk measures were simulated and the way in which they may be applied to risk management was examined.

---

[42] This range of values has been observed in the South African market at times of extreme market volatility (van Veen, 2005).

5.4. Beta

Using the portfolio described above, the betas shown in Figure 5.2 were obtained. The portfolio beta of this combination of share weights is +0.17. This positive portfolio beta arises from two components: the share weights and the constituent betas. A market neutral fund requires that the portfolio beta equals zero. To reduce the portfolio beta for the portfolio shown in Figure 5.2 below to zero, one of two routes may be followed. Either the weights of the shares on the long side could be reduced (by selling a portion of the share investment) or the weights of the shares on the short side of the portfolio could be increased (by selling even more of the share investment). The degree of reduction is greater the higher the beta (OMAM, 2004a).

Figure 5-2 Original portfolio beta and corresponding portfolio weights.

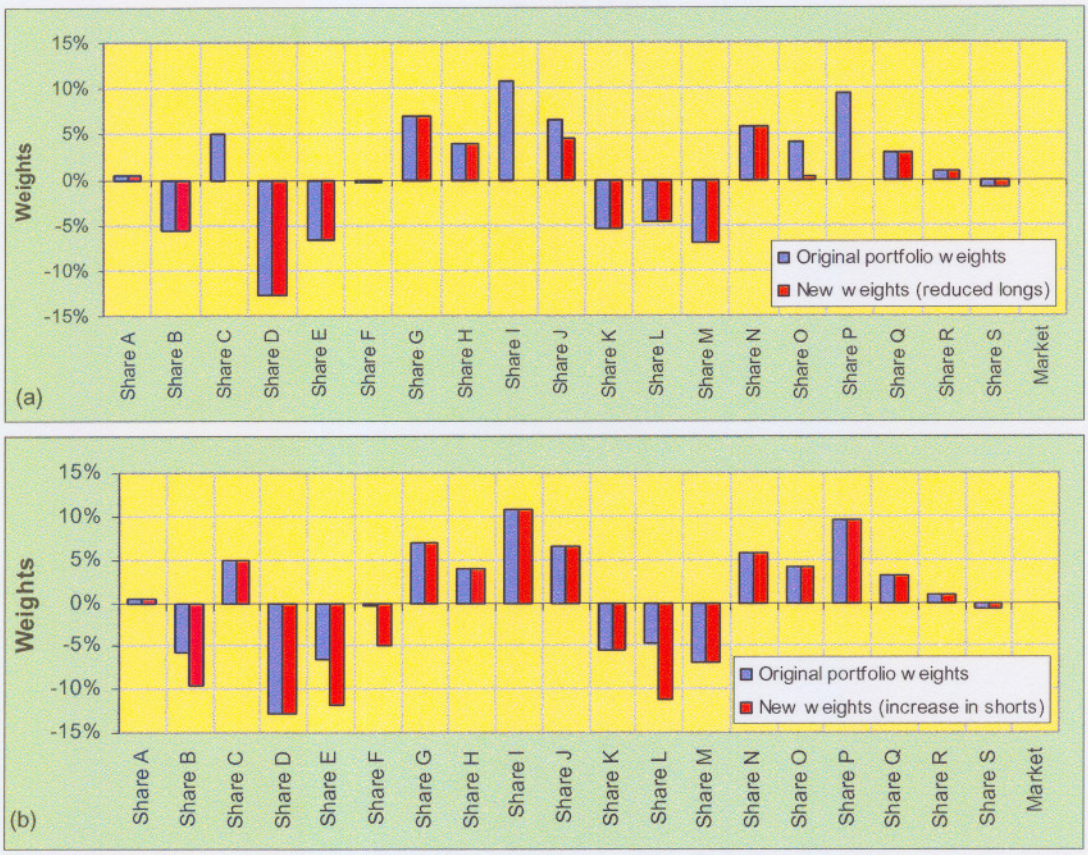


The risk of this portfolio may now be managed. It is clear from Figure 5.2 that the portfolio comprises more investment on the long side than on the short side. Reducing the investment in those shares on the long side of the portfolio (especially those with high betas) provides one possibility (Figure 5.3a). Another option would be to increase the investment in those shares on the short side (Figure 5.3b).

This method of portfolio beta balancing is popular amongst managers that follow a market neutral strategy. Some managers of long short funds manage their portfolio beta to take advantage of the expected direction of the market. For example, if the fund manager expects the market to decrease the portfolio will be manipulated in such a way that a negative beta is achieved. Similarly, if a market increase is expected a positive beta is required.

The important VaR measure is considered next as a tool to manage hedge fund risk.

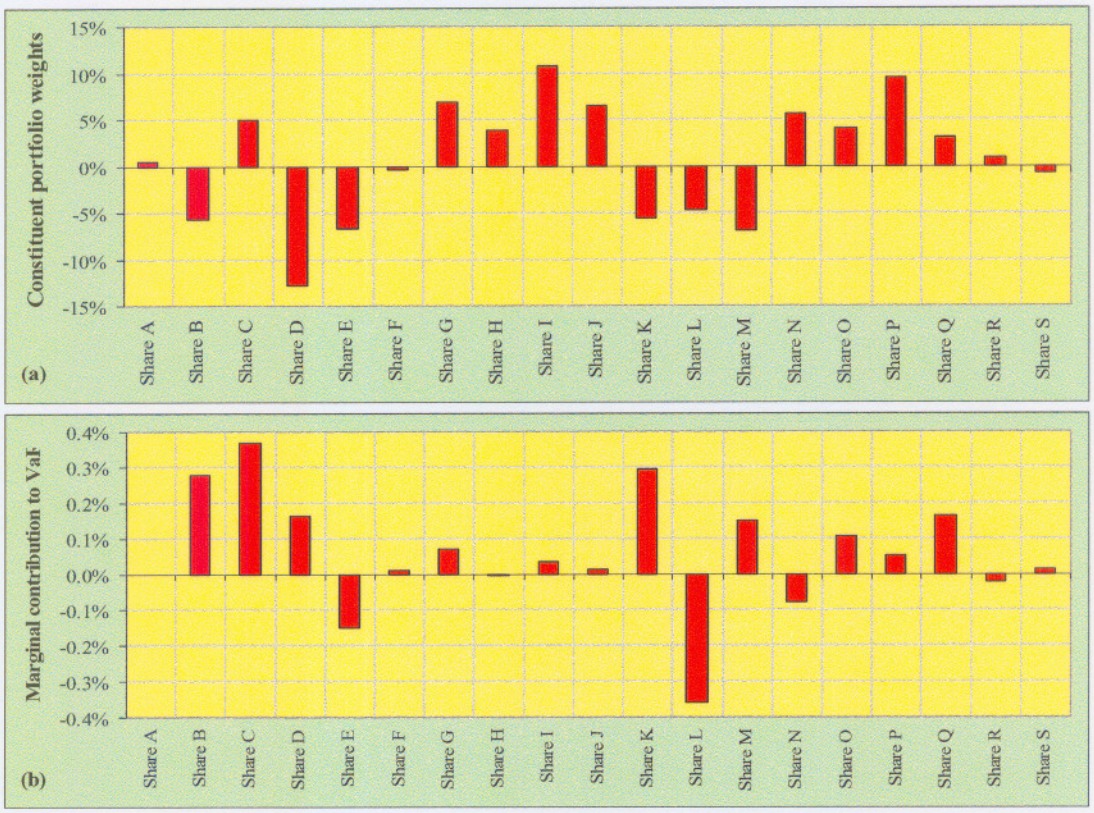
Figure 5-3 Adjusted portfolio beta with corresponding portfolio weights for (a) reduced long positions and (b) increased short positions.



5.5. VaR

Using the parameters to construct a portfolio described in Section 5.2, a portfolio comprising shares of random weights was generated (Figure 5.4a). To calculate the VaR for this portfolio, Equation 4.9 was used. A notional investment amount of R1m, a confidence interval of 95% and an unwind period of 5 days were chosen. The volatilities and correlations used were constructed as discussed in Section 5.2 to generate the variance covariance matrix. Marginal contribution to VaR was calculated by changing the constituent share weights by 1% in turn, and measuring the change in VaR from the original portfolio VaR (Jorion, 1996:167). This difference, expressed as a percentage of the portfolio value is the marginal VaR and is shown in Figure 5.4b below.

Figure 5-4 Portfolio weights (a) and marginal contribution (b) to VaR.



The magnitude of the marginal contribution to VaR is directly related to the magnitude of the underlying share's volatility, whilst the sign of the marginal contribution is

determined by the correlation of the share with the market (Marshall, 1996).

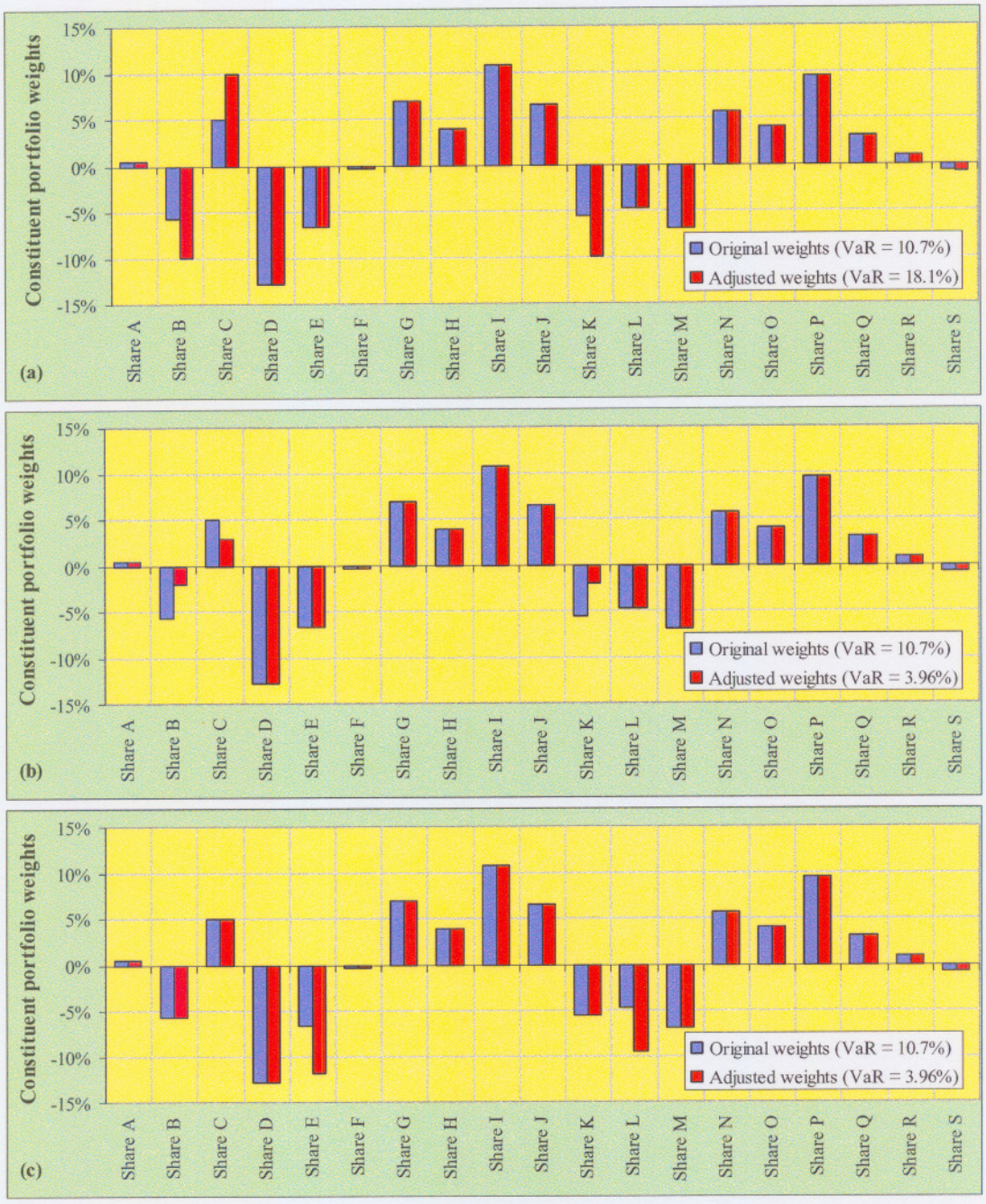
A negative marginal contribution to VaR arises when the correlation of the overall portfolio with the market is *positive*, but the relevant share has a *negative* correlation with the market. The same applies when the overall portfolio correlation with the market is *negative* and the correlation of the relevant share with the market is *positive* (Ernst and Young, 2005).

The portfolio VaR of this combination of share weights is 10.71% of the original investment amount. This value may be increased or decreased, depending on the hedge fund manager's risk appetite (Matz, 2005:17). To increase the VaR – which may be a mandate requirement – the hedge fund manager could increase the weights in those shares with the highest marginal contribution to VaR (in this case, for example, shares B, C and K). To decrease the VaR – if the portfolio is perceived to be too risky – one option might be to reduce the weight in those shares that contribute positively to the VaR. Another way to achieve this would be to increase the weights in those shares which have a negative contribution to the marginal VaR (in this case, shares E and L, Jorion, 2001:142). These scenarios are shown in Figure 5.5a through c below. Figure 5.5a shows the original portfolio weights in blue and the increased weights in some shares that contribute positively (shares B, C and K) to the marginal VaR in red. This has the effect of increasing the VaR from 10.7% to 18.1%. Note that a reduction of the weight in a negative position results in an even larger negative weight. An increase in the weight in a positive position results in a larger positive weight.

Figure 5.5b again shows the original portfolio weights in blue and the decreased weights in some shares that contribute positively to the marginal VaR in red. This results in a change of VaR from 10.7% to 3.9%.

Finally, Figure 5.5c shows the effect of increasing the weights in shares (E and L) that contribute negatively to marginal VaR. This also has the effect of reducing the VaR from 10.7% to 3.9%.

Figure 5-5(a) Increased VaR and (b) decreased VaR by increasing weights and (c) decreased VaR by decreasing weights.



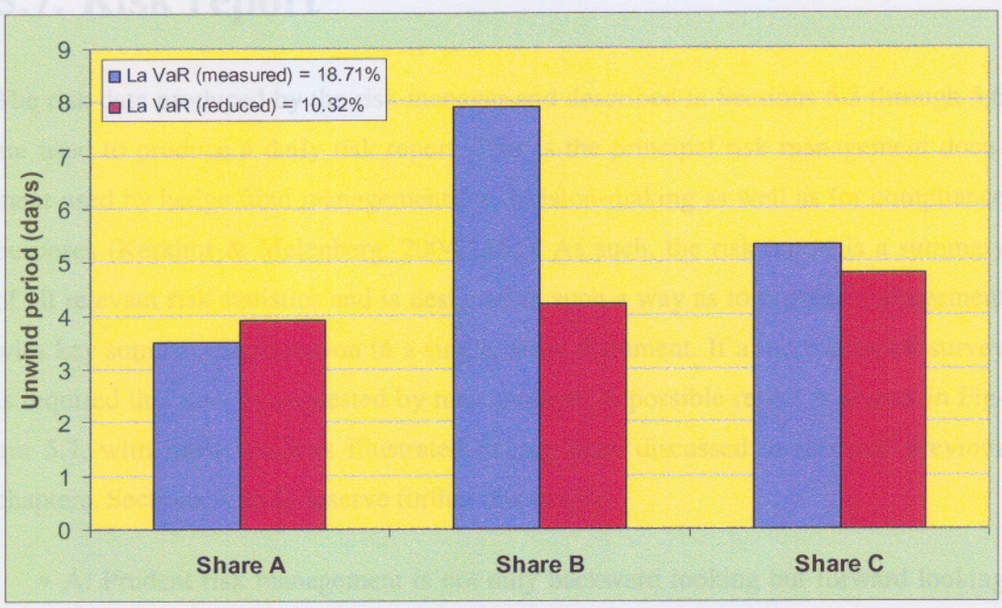
In practice, portfolio VaR is managed through the purchase and short selling of shares from a universe much broader than the one under consideration in this example. This simple example demonstrated risk management in a portfolio of shares through the adjustment of the portfolio constituent investment amounts.

The liquidity of the portfolio constituents has not been taken into account in this section. In practice, liquidity is an important component of the risk of any fund and must be managed accordingly. This effect on VaR is discussed in the next section.

5.6. La-VaR

The previous section made the inherent assumption that all constituent shares enjoyed the same unwind period of 5 days, and hence were of identical liquidity. In practice, this is never the case: shares have widely differing liquidities due to different stock availability and price, company size and so on. A new way of accounting for these differences was discussed in detail in Section 4.5. The longer the unwind period of the portfolio constituent, the higher the La-VaR, and the shorter the unwind period, the lower the La-VaR (OMAM, 2004c). To risk-manage a hedge fund portfolio from an La-VaR point of view, a hedge fund manager would adjust the weights in (i.e., sell) shares with longer unwind periods until the mandated VaR level was reached (Coles, 2001:54). The equations governing the estimate of this reduction are given in Section 4.5. Figure 5.6 shows the measured unwind periods for three component shares, and the associated La-VaR at 18.71%.

Figure 5-6 La-VaR (measured) and after risk management adjustment.



attacks on New York further dented the then fragile world economy in unpredicted ways. Using economic data from the market prior to, during, and subsequent to these events provides invaluable input information to the ongoing quest for effective risk management.

If risk management believes share B to have too long an unwind period (i.e. the contribution to La-VaR is excessive compared to the other portfolio constituents), it will be suggested to the hedge fund manager that the position in this share should be reduced (Gibson, 2004:168). Whilst this position reduction may take a number of days to effect, if this process takes place gradually endogenous liquidity risk (Section 4.5.1.1) is managed.

The risk measures described in sections 5.3 through 5.6 will all form part of a daily risk report. Such a report is discussed in the following section.

5.7. Risk report

The risk data produced by the risk manager and described in Sections 5.3 through 5.6 are used to produce a daily risk report. This is the principal risk management document used by hedge fund management for decision-making as well as for compliance purposes (Kerkhof & Melenberg, 2004:1851). As such, the risk report is a summary of all relevant risk statistics and is designed in such a way as to provide management with key summary information in a single, short document. If a more detailed survey is required this may be requested by management. A possible report is shown in Figure 5.7, with most statistics illustrated having been discussed in this and previous chapters. Sections A to D deserve further discussion.

- A: Prudent risk management is not only backward looking but forward looking as well. Examination of prevailing market conditions during previous financial crises can yield useful insights into the management and prevention of future crises. For example, the Asian crisis of 1998 (Lowenstein, 2001) gave rise to the evaporation of liquidity to unprecedented levels worldwide. The April 2000 dotcom crash crippled tech stock indices globally, and the September 11 2001 attacks on New York further dented the then fragile world economy in unpredicted ways. Using economic data from the market prior to, during, and subsequent to these events provides invaluable input information to the ongoing quest for effective risk management.

Figure 5-7 Example of daily hedge fund risk report.

Daily risk report

Shares currently in portfolio.

(a)	Share A	Share B	Share C
Weights	0.49%	-5.64%	4.99%

Volatilities.

	Share A	Share B	Share C
Volatilities	0.34	0.47	0.75

Correlation table.

	Share A	Share B	Share C
Share A	1	0.82	0.53
Share B	-0.22	1	-0.74
Share C	0.16	-0.74	1

Unwind period under normal market conditions.

	Share A	Share B	Share C
Unwind period	3.5 days	7.9 days	5.3 days

A

Unwind period under stressed market conditions.

	Share A	Share B	Share C
Unwind period	4.7 days	12.6 days	5.3 days

Beta

	Share A	Share B	Share C
Beta	0.60	1.62	0.24

B

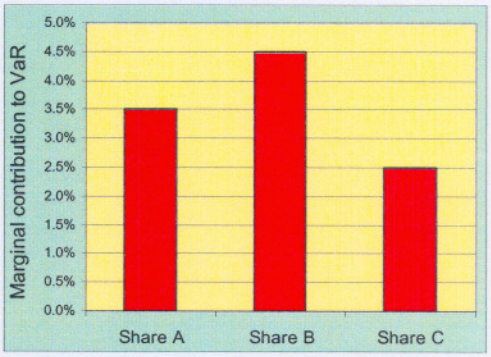
Derivative exposures

	Exposure
Options	1.20%
Futures	2.10%

Portfolio Risk statistics.

	Share A
VaR	10.71%
LaVaR	18.73%
Beta	0.17
Sharpe Ratio	3.61
Sortino Ratio	12.92
Drawdown	2.01%
Recovery period	1m

Marginal contribution to VaR



C

Markets

Market 1	1.20%
Market 2	0.98%
Currency	6.34
Oil price	$53
Gold price	$376

D

P & L

	Portfolio
Day	0.49%
Week	0.87%
Month	1.36%
Year	23.01%

- Far-sighted risk management will include stress testing data in daily risk reports. Liquidity is not the only risk factor that could be stressed: interest rates (if interest rates sensitive instruments are used), oil prices, foreign exchange rates, gold price and inflation rates are also often scenario-tested.

- B: Any portfolio which comprises derivatives is subject to significant risk. Derivative instruments are highly sensitive to interest rate movements, changes in market volatility, underlying instrument prices and changes in the passage of time. Exposures to these risks can be significant and must be constantly managed. The risk associated with derivatives is, however, a wide and deep field, and has been the subject of much research. It is not in the scope of this dissertation to focus on these risks.

- C: Market information provides a snapshot of prevailing economic conditions which supplies crucial decision making information for hedge fund management. Here, savvy experience of previous market conditions plays a crucial role in the formulation and implementation of strategic investment decisions.

- D: P&L data are not specifically risk-reported statistics, but they nevertheless supply important information for management and must be reported on a daily basis.

5.8. Conclusion

The ultimate aim of prudent risk management is not the accurate measurement of risk (which is useless in isolation), but the matching of risk appetite to the measured portfolio risk. This chapter applied the measurement of risk – discussed in the previous chapter – to the management of risk in a hypothetical portfolio.

A summary of this dissertation, conclusions reached and an outline of potential new and interesting project directions are presented in the next, final chapter.

Chapter 6

Summary, conclusions & suggestions for future work

6.1. Summary

Hedge funds encompass broad alternative investment strategies and require skill-based investing strategies rather than risk based investing strategies which are required for bonds and equities. Hedge funds represent separate investment pools, managed by individuals or firms that use a variety of financial instruments and employ active trading, value investing or portfolio management techniques to

- seek gains regardless of the direction of traditional equity or bond markets
- exploit mispricings or inefficiencies in capital markets or
- profit or benefit from prudent risk management.

Hedge funds have historically provided the opportunity for a superior/return profile and can provide active (business) returns rather than passive (index) or asset class returns.

At present the hedge fund industry is largely unregulated and this has led to much investor concern about the management of risk in hedge funds. The demonstration of prudent risk management is therefore of critical import. Measuring and managing these risks are not only important from an investor's confidence point of view, but are also vital elements for hedge fund management. This dissertation focused on the basic definition of hedge funds, their historical evaluation and the various styles of management used for hedge fund investments. In addition the few regulatory rules that do apply to hedge funds were explored, performance measurement was examined and relevant hedge fund risk parameters were detailed. The use of these risks to successfully risk-manage a hedge fund was also discussed.

6.2. Conclusions

There are a variety of risk measures available to the prudent hedge fund manager. These measures provide the tools for effective risk management, but great care must be taken not to ignore the warning signals these tools provide nor to make use of these in isolation. Investor confidence was severely dented with the 1998, highly-publicised collapse of Long Term Capital Management – a massive US hedge fund. Whilst some investors' confidence has returned, many are still wary, and the lack of regulation has frightened many risk-averse investors off the hedge fund track. Despite this enormous quantities of money continue to pour into these funds and the trend shows no sign of stopping. It is vital that visible risk management be consistently exercised and self regulation be employed. These aspects of hedge funds feature high on the list of investor demands.

Interesting features of some risk measures, such as the differential scaling in time of risk and return, the time-dependence of the exponentially weighted moving average factor and the omission of portfolio liquidity adjusted value at risk from contemporary hedge fund risk reports were examined in detail and promising new directions were explored in this dissertation.

These suggestions have been implemented in some South African hedge funds with great success, but the quest for improved measures will continue as new hedge funds evolve and risks arise from their novelty.

6.3. Suggestions for future work

The scope for improvement of hedge fund risk measures is vast and ongoing. The new measures suggested in this dissertation, for example, could be tested on other funds described in Chapter 2, the liquidity-adjusted value at risk could be expanded to include the effects of altering other parameters required for its measurement.

A liquidity-adjusted beta value would also benefit from ongoing new research and detailed exploration of promising new ratios (such as the Omega ratio) will ensure that the hedge fund risk management arena continues to be a fertile area of study.

References

- ACKERANN, C., MCENALLY, R., & RAVENSCRAFT, R. 1999. The performance of hedge funds: risk, return and incentives. *The journal of finance LIV*: 44–72, Jun.
- AGARWAL, V. & NAIK, N.Y. 1999. On taking the alternative route: Risks, rewards style and performance persistence of hedge funds. Institute of accounting and finance, Department of finance, London Business School, 22p. Feb.
- AIMA. 2002. Hedge fund booklet, Australia. [Internet:] http://www.asx.com.au/markets/pdf/Assirt_Hedge_Fund_Booklet.pdf [Date of use. Sep 4]
- AIMA. 2003. AIMA's second international regulatory forum. *AIMA Journal,* 58: 1-23. Sep.
- AIMA. 2004. The regulatory position of hedge funds in South Africa - a joint discussion paper. *Hedge funds: Proposed regulatory approach*, p. 1–41, Nov.
- ALEXANDER, C. 2001. Market models: A Guide to financial data analysis. Wiley Publishing: London. 229 p.
- ALLEN, M. 1994. Building a role model. *Risk,* 7:73-80, Sep.
- ALMGREN, R. & CHRISS, N. 1999. Value under liquidation. *Risk,* 12:58–64, Dec.
- ALTERNATIVE INVESTMENT MANAGEMENT ASSOCIATION see AIMA.
- ARCHER, J. 2005. Portfolio optimization. [Internet:] http://tecom.cox.smu.edu/esnir/S05/itom6214/6214S05Lecture7.pdf [Date of use: Sep. 4]
- ASNESS, C. 2004. An alternative future: Part II; an exploration of the role of hedge funds. *Journal of portfolio management,* 31(1):8–23.
- ASNESS, C., KRAIL, R. & LIEW, J. 2001. Do hedge funds hedge? *Capital management* LLC: 2–19, May.
- BAILEY, W., LI, H. & ZHANG, X. 2004. Hedge fund performance evaluation: A stochastic discount factor approach. [Internet:] http://www.rotman.utoronto.ca/finance/seminars/041105_li.pdf [Date of use: Sep. 18]
- BANGIA, A., DIEBOLD, F.X., SCHUERMANN, T. & STROUGHAIR, J. 1998. Modelling liquidity risk. [Internet:] http://www.ssc.upenn.edu/~fdiebold/papers/paper25/bds.pdf. [Date of use: Dec. 2]

- BANGIA, A., DIEBOLD, F.X., SCHUERMANN, T. & STROUGHAIR, J. 1999. Liquidity on the outside. *Risk,* 12:68-73, Dec.

- BARRA ROGERSCASEY. 2001. An introduction to hedge funds. *The first in the BRC hedge fund series,* p. 9–13

- BEDER, T. 1995. VaR: seductive but dangerous. *Financial analysts journal,* 51:12-24, Sep–Oct.

- BIS, 1988. International convergence of capital measurement and capital standards. [Internet:] http://www.bis.org/publ/bcbs04a.htm [Date of use: Nov. 15]

- BIS, 2004. International convergence of capital measurement and capital standards: a Revised framework, [Internet:] http://www.bis.org/publ/bcbsca.htm [Date of use: Nov. 15]

- BODIE., Z., KANE, A. & MARCUS, A.J. 1999. Investments. 4th ed. Singapore: McGraw-Hill. 967p.

- BOLLERSEV, T., CHOU, R. Y. & KRONER, K. F. 1992. ARCH modelling in finance: a selective review of the theory and empirical evidence. *Journal of econometrics*, 52:5-59.

- BOTHA, M., VAN VUUREN, G.W. & STYGER, P. 1999. The silence of the lambdas. *A risk special report, Risk supplement*, p. 18—23, Jun.

- BOTHA, M., VAN VUUREN, G.W. & STYGER, P. 2001. The effect of a dynamic exponential decay factor on volatility and VaR. *PJAS,* 1: 24–32, Jan.

- BOUCHAUDY, J. P. & POTTERSY, M. 1999. Worse fluctuation method for fast Value-at-Risk estimates. Service de physique de l'etat condense. Centre d'etudes de Saclay, Sep.

- BRADLEY, P. Z., WILLIAM, J.D., FOURI.E., I. & SMITH, A. 2000. Analysis of the hedge fund investors community: South Africa. (*In* Arthur Andersen ed. Summary of findings from interviews conducted in Johannesburg and Cape Town, South Africa. Johannesburg p. 1 – 7) Feb.

- BROWN, S. J., GOETZMANN, W. N. & LIANG, B. 2003. Fees on fees in funds of funds. *NBER working paper*, 9464:1–4, Feb.

- BROWN. S. J., GOETZMANN, W.N. & PARK, J. 1998. A hitchhiker's guide to hedge funds. *The Economist,* p. 1–2, Jun.

- BURCHELL, E. 2005. Investment company act of 1940. [Internet:] http://www.aspenpublishers.com/SECRULES/invact40.pdf. [Date of use: May. 1]

- BUTLER, J. S. & SCHACHTER, B. 1996. Improving Value-at-Risk estimates by combining kern-estimation with historical simulation. Vanderbilt University, Nashville Comptroller of the Currency. 13 p.

- ÇETIN, U., JARROW, R. A., PROTTER, P. & WARACHKA, M. 2004. Option

pricing with liquidity risk, [Internet:] http://www.orie.cornell.edu/~protter/WebPapers/bspaper3.pdf [Date of use: Nov. 8]

- CLERMONT, D. 2003. Don't pay for beta, seek out alpha and avoid settling for at-par market returns. [Internet:] http://www.investmentreview.com/archives/2004/spring/AIC_clermont.pdf [Date of use: Sep. 4]

- COLES, S. 2001. An introduction to statistical modelling of extreme values. University of Bristol. 208p.

- COSANDEY D. 2001. Adjusting Value-at-Risk or market liquidity. *Risk,* 10:115–118, Oct.

- COX, J., INGERSOLL, J. & ROSS, S. 1985. A theory of the term structure of interest rates. *Econometrica*, 53:385–408.

- CRNKOVIC, C. & DRACHMAN, J. 1995. A universal tool to discriminate among risk measurement techniques. *Risk,* 12:74–83, Dec.

- CROMWELL, J. B., LABYS, W. C. & TERRAZA, M. 1994. Univariate tests for time series models. Sage, Thousand Oaks, CA:20–22.

- DAMODARAN, A. 2003. Estimating risk parameters. Stern school of business, New York, NY 10012 [Internet:] http://pages.stern.nyu.edu/~adamodar/pdfiles/papers/beta.pdf. [Date of use: Jan. 14]

- DANIELSSON, J. & DE VRIES, C. G. 1997. Extreme returns, tail estimation, and Value-at-Risk. University of Iceland, Tinbergen Institute, Erasmus University. 22p.

- DE LA TORRE, A. 2005. Coping with risks through mismatches: domestic and international financial contracts for emerging economies. *International Finance,* 7:1-42; 309-315.

- DE SOUSA, C. & GOKCAN, S. 2003. AIMA survey of hedge fund classification practice. *AIMA journal*, 58:11-12, Sep.

- DIEBOLD, F. X. & LOPEZ, J. 1996. Modelling volatility dynamics, in Kevin Horner (*ed*): Macroeconomics: developments, tensions and prospects. Boston: Kluwer Academic Press. 721p.

- DIEBOLD, F. X., HICKMAN, A., INOUE, A. & SCHUERMAN, T. 1996. Converting 1-day volatility to h-day volatility: scaling by $\sqrt{h}$ is worse than you think. [Internet:] http://www.ssc.upenn.edu/~diebold/ [Date of use: Mar. 3]

- DOWD, K. 1998. Beyond Value-at-Risk. England: John Wiley & Sons Ltd. 342p.

- DOWNES, J. 2003. Dictionary of Finance and Investment Terms. New York: Barrons. 818p.
- EDWARDS, F. R. 1999. Hedge funds and the collapse of long term capital management. *Journal of economic perspective,* 13(2):189–210, Spring.
- ENGLE, R. F. & SHEPPARD, K. 2001. Theoretical and empirical properties of dynamic conditional correlation multivariate. *NBER working paper,* W8554:1–6, Feb.
- ERNST AND YOUNG. 2005. VaR model procedures. *Internal Report. GVV 12*
- ERWAN, L. 2002. Incorporating liquidity risk in VaR Models. [Internet:] http://www.gloriamundi.org/picsresources/els.pdf [Date of use: Jun. 4]
- ESTRELLA, A., HENDRICKS, D., KAMBHU, J., SHIN, S. & WALTER, S. 1994. The price of options positions: measurement and capital requirements. *Federal Reserve Bank of New York,* Quarterly Review. p. 27–43, Fall.
- FABOZI, J. 2000. Fixed income analysis for the chartered financial analyst program. Illinnois:Academic Press. 938p.
- FALLON, W. 1996. Calculating Value-at-Risk. Wharton school of financial institutions working paper series. *Working paper* 104: 96-149.
- FERNANDEZ, F. A. 1999. Liquidity risk: New approaches to measurement and monitoring. [Internet:] http://www.sia.com/research/pdf/workingpaper.pdf [Date of use: Jun. 5]
- FILD, L. 2005. Introducing South Africa's first ever hedge fund performance awards. *Mathworld,* [Internet:] http://www.oldmutula.co.za/pressrelease/article.asp?id=121 [Date of use: Feb. 27]
- FINANCIAL Services Board Coordinating Committee see SOUTH AFRICA.
- FINNEGAN, G. W. 2005. An Introduction to matrix algebra and multiplication. [Internet:] http://www.fenews.com/fen39/back_to_basics/Back%20to%20Basics%20Column-formulas.htm [Date of use: Mar. 6]
- FISCHER INVESTMENTS. 2001a. Information Ratio. *Investopedia,* [Internet:] http://www.investopedia.com/terms/i/informationratio.asp [Date of use: Sep. 8]
- FISCHER INVESTMENTS. 2001b. Introduction to Value-at-Risk (VAR) – Part 1. *Investopedia,* [Internet:] (http://www.investopedia.com/articles/04/092904.asp) [Date of use: Jan. 8]
- FISCHER INVESTMENTS. 2001c. Sharpe Ratio. *Investopedia,* [Internet:] http://www.investopedia.com/offsite.asp?URL=http://www.the401k.com/news/quarter11997/Sharpe_ratio.html [Date of use: Sep. 8]

- FISCHER, B. 1999. Hedge fund industry presented to Hermes Global Holdings Company (Cayman) Limited, *Ing Furman Selz Asset Management,* p.3 – 71. Sep.

- FRIEDLAND, D. 2003. Global macro investing: Interview with Douglas Make-peace. [internet:] http://www.thehfa.org/AboutUs.cfm [Date of use: Nov.12]

- FTSE. 2004. Guide to hedge funds. [Internet:] http://www.ftse.com/indices_marketdata/ftsehedge/hedgeguide.pdf [Date of use: Jul. 24]

- FULKES, B. 1998. Sharpe ratio. [Internet:] http://www.miapavia.com/homes/ik2hlb/sr.htm [Date of use: Jul. 24]

- FUTURES, C., BURGHARDT, G., DUNCAN, R. & LIU, L. 2003. Deciphering drawdown. *Risk,* 9:14–17, Sep.

- GABELLI. 2003. The hedge fund. [Internet:] http://gabelli.com/news /mario-hedge_102500.html. [Date of use: Sep. 12]

- GIBSON, R. & MOUGEOT, N. 2004. The pricing of systematic liquidity risk: Empirical evidence from the US stock market. *Journal of banking & finance*, 28(1):157-178.

- GLASSERMAN, J. 2002. Portfolio Value-at-Risk with heavy-tailed risk factors. *Mathematical Finance*, 12(3):239–269, Jul.

- GOODSPEED, I. 2004. Introduction to financial markets. *SAIFM,* p. 63, Jan.

- GRINBLATT, M. & TITMAN, S. 1998. Financial markets and corporate strat-egy. Singapore: McGraw-Hill. 866p.

- GUJARATI, D. N. 1995. Basic econometrics. 3rd ed. McGraw-Hill International Editions, Economic Series. 74p.

- HEATH, D., JARROW, R. & MORTON, A. 1992. Bond pricing and the term structure of interest rates: A new methodology for contingent claims valuation. *Econometrica,* 60:77-105.

- HEDGE FUND RESEARCH. 2004. Hedge fund industry report. [Internet:] https://www.hedgefundresearch.com/ia_register/index.php?fuse=login&1109931157 [Date of use: Mar. 2]

- HEDGE FUNDS WORLD. 2005a. The Nordic hedge fund market. [Internet:] http://www.hedgefundsworld.com [Date of use: Mar. 5]

- HEDGE FUNDS WORLD. 2005b. The Asia's dedicated fund of funds confer-ence. [Internet:] http://www.hedgefundsworld.com [Date of use: Mar. 5]

- HEDGE WORLD. 2003. Hedge fund basics. [Internet:] http://www.hedgeworld.com/research/education.cgi?page=hedge_fund_basics [Date of use: Nov. 12]

- HOLTON, G. A. 2003. Value-at-Risk: theory and practice. *Academic Press*, ISBN: 0123540100, 405p.
- HONOR, P. 1998. Panel-data estimation of non-linear term-structure models. [Internet:] http://www.cls.dk/caf/wp/wp-19.pdf [Date of use: Nov.18]
- HUBBERT, S. 2004. Risk management: Monte Carlo simulation. [Internet:] http://www.econ.bbk.ac.uk/faculty/hubbert/MCVaR.pdf [Date of use: Feb. 16]
- HULL, J. & WHITE, A. 1990. Pricing interest-rate derivative securities. *Review of financial Studies*, 3:573–592.
- HULL, J. & WHITE, A. 1993. Bond option pricing based on a model for evolution of bond prices. A*dvances in futures and options research*, 6:1–13.
- HULL, J.C. 1997. Options, futures & other derivatives. 3rd ed. New Jersey: Prentice-Hall. 698p.
- HULL, J.C. 2000. Options, futures & other derivatives. 4th ed. New Jersey: Prentice-Hall. 347p.
- IMF. 2000. Background note on the hedge fund Industry. *Financial stability forum.* Annex D, p.78–102.
- INDJIC, D. & HEEN, A. 2003. AIMA survey of hedge fund classification practice. *AIMA Journal*, 58:1, Sep.
- INTERNATIONAL ORGANIZATION OF SECURITIES COMMISSION see IOSCO.
- INVESTORWORDS. 1997. Sortino ratio. [Internet:] http://www.investorwords.com/5793/Sortino_ratio.html [Date of use: Oct. 9]
- IOSCO. 1999. Hedge funds and other highly leveraged institutions. *Report for the technical committee of IOSCO*, p.32-42, Nov.
- IOSCO. 2003. Regulatory and investment protection issues arising from the participation by retail investors in (funds of) hedge funds. *Report for the technical committee of IOSCO*, p.55-78, Nov.
- IVOLATILITY.COM. 2005. Ways to estimate volatility. [Internet:] http://www.ivolatitly.com/help/6.html. [Date of use: Apr. 30]
- J'OHRI, S. 2004. Portfolio optimization with hedge funds: Conditional Value-at-Risk and conditional draw-down at risk for portfolio optimization with alternative investments. [Internet:] http://e-collection.ethbib.ethz.ch/ecol-pool/dipl/dipl_127.pdf [Date of use: Jan. 20]
- JACKSON, M. & STAUNTON, M. 2004. Advance modelling in finance using Exel asn VBA. England:John Wiley & Sons Ltd. 125p.
- JACKSON, P., MAUDE, D. J. & PERRAUDIN, W. 1997. Bank capital and

Value-at-Risk. *Journal of derivatives,* 4:73-90, Spring.

- JARROW, R. & SUBRAMANIAN, A. 1997. Mopping up liquidity. *Risk,* 12:170-173, Dec.
- JARROW, R. & SUBRAMANIAN, A. 2001. The liquidity discount. *Mathematical finance*, 11(4):447-474.
- JORION, P. 2001. Financial risk manager handbook: 2001 – 2002, GARP, *Wiley Finance*, John Wiley and Sons. 215p.
- JORION, P. 2004. Value-at-Risk: the new benchmark for managing financial risk. 2nd ed. New Jersey: McGraw-Hill. 548p.
- JORION, P. AND KHOURY, S. J. 1996. Financial risk management. Blackwell:New York. 320p.
- JP MORGAN, 1996. RiskMetrics™ Technical document, 4th ed., New York. 68p.
- KAZEMI, H. & SCHNEEWEIS, T. 2003. Conditional performance of hedge Funds, Working Paper, CISDM. p. 23
- KERKHOF, J. & MELENBERG, B. 2004. Backtesting for risk-based regulatory capital. *Journal of banking & finance,* 28(8):1845-1865.
- KIYOSAKI, R.T. & LECHTER, S.L. 1997. Rich dad's guide to investing. New York: Warner Books. 405p.
- KLUGMAN S., PANJER H. & WILLMOT G. 1998. Loss models from data to decitions. New York: John Wiley & Sons inc. 31p.
- KWAN, C. K., LI, W. K. & NG, K. 2005. A multivariate threshold GARCH model with time-varying correlations. [Internet:] http://www.ims.nus.edu.sg/Programs/econometrics/files/wkl_paper.pdf [Date of use: Jan. 17]
- L'HABITANT, F. S. 2000. Hedge funds and investment partnerships: a primer. Discussion Paper, Thunderbird. p. 2 – 6.
- L'HABITANT, F. S. 2001. Assessing market risk for hedge funds and hedge fund portfolios. *The journal of risk finance*, 2(4):16–32.
- LAKE, R.A. 2004. Evaluating and implementing hedge fund strategies: the experience of managers and investors. 3rd ed. London: Euromoney Books. 392p.
- LANDAU, P. 1968. Alfred Winslow Jones: The long and the short of the founding father. *Institutional investor,* p. 1-13, Aug.
- LAWRENCE, C. & ROBINSON, G. 1998. Liquidity, dynamic hedging and Value-at-Risk. *Risk management for financial institutions, Risk Pubs,* p. 63-72.

- LE SAOUT, E. 2001. Incorporating liquidity risk in VaR Models. [Internet:] http://www.eco.fundp.ac.be/affi2001/I8.pdf [Date of use: Jun. 5]

- LINSMEIER, T.J., & PEARSON, N.D. 1996. Risk measurement: an Introduction to Value-at-Risk. University of Illinois at Urbana-campaign. 45p. Jul.

- LONGSTAFF, F. A. & SCHWARTZ, E. S. 2001. Valuing American options by simulation: A simple least square approach. *Review of Financial Studies,* 1:113-147.

- LOWENSTEIN, R. 2001. When genius failed: The rise and fall of long term capital management. New York: Random House Trade. 96p.

- MALKIEL, B. G. & SAHA, A. 2004. Hedge funds: Risk and return. [Internet:] http://www.iamgroup.ca/eduCentre/articles/Hedge%20Funds%20%20Risk%20& %20Return.pdf [Date of use: Mar. 3]

- MARCUS, M. & MINC, H. 1988. Introduction to linear algebra. New York: Dover.182p.

- MARHEDGE. 2001. Hedge fund styles. [Internet:] http://www.marhedge.com/mar/paq_hsty.htm [Date of use: Sep. 4]

- MARKS, H. 2005. Oaktree asset management. [Internet:] http://www.oaktreecapital.com/OCM_Public/is_strat.asp [Date of use: Mar. 2]

- MARSHALL, C. & SIEGEL, M. 1996. Value-at-Risk: implementing a risk measurement standard. *Journal of Derivatives*, 4:91-111.

- MASON, R.D., LIND, D.A. & MARCHAL, W.G. 1999. Statistical techniques in business and economics. 10th ed. Boston: McGraw-Hill. 788p.

- MATHIESEN, H. 2004. Model: The CAP model (CAPM) [Internet:] http://www.encycogov.com/A2MonitorSystems/AppA2MonitorSystems/AppBtoA2CAP_model/CAP_Model.asp [Date of use: Jan. 14]

- MATZ, L. 2005. Use and misuse of Value-at-Risk analysis for bank balance sheet risk analysis. *Bank accounting & finance*, p. 15-20, Dec – Jan.

- MCCREARY, J. 2000. Various estimations of Π as demonstrations of the Monte Carlo method. [Internet:] http://www.math.tntech.edu/techreports/TR_2001_4.pdf [Date of use: Feb. 16]

- MCNEIL, A. J. 1996. Estimating the tails of loss severity distributions using extreme value theory. *Mimeo*, ETH Zentrum, Zürich. p. 1 - 49

- MORLEY, I. 2004. Hedge fund indices: a measure of performance or the hangman's noose for hedge funds? *AIMA Journal*, 61:1-10, Apr.

- MULVEY, J. 2003. The role of hedge funds for long-term investors. *Journal of financial transformation*. p. 4 – 7.

- NICHOLAS. J.G. 1999. Investing in hedge fund strategies for the new market-place. New Jersey: Bloomberg Press. 356p.
- OLD MUTUAL. 2005. Recognising South Africa's top performing hedge funds. [Internet:] http://www.oldmutual.co.za/PressRelease/article.asp?id=138 [Date of use: Feb. 16]
- OMAM. 2004a. Hedge fund risk manual. *Internal Report, VV 206.*
- OMAM. 2004b. Exponentially weighted moving average volatility: Methods and measurement. *Internal Report, IK 126.*
- OMAM. 2004c. Liquidity adjusted Value-at-Risk: Methods and measurement. *Internal Report, MB 84.*
- OWENS, J.P. 2003. Different styles of hedge funds and their attributes [Internet:] http://www.independenthedge.com/different.html [Date of use: Nov. 3]
- PALANDRI, A. 2004. Multivariate GARCH models: inference and evaluation, Department of Economics, Duke University, Durham, NC 27708. [Internet:] http://www.duke.edu/~ap34/mgarch4.pdf [Date of use: Jan. 17]
- PAYANT, R. 1996. Why VaR is in vogue. *Balance sheet,* 5:3–5.
- PESKIN, M.W., ANJILVEL, S.I., BOUDREAU, B.E. & URIAS. M.S. 2000. Why hedge funds make sense. *Global equity and derivative markets,* p. 2 – 17, Nov.
- PHYSICSNET. 2005. Additions of two vectors [Internet:] http://www.ac.wwu.edu/~vawter/PhysicsNet/Topics/Vectors/VectorAddation.htm [Date of use: Mar. 6]
- POLYN, G. 2001. Hedge funds placed under the microscope. *Risk*, 8:12, Aug.
- PRITSKER, M. 2001. The hidden dangers of historical simulation. [Internet:] http://www.ise.ufl.edu/rmfe/seminar/Pritsker/abstract_Pritsker.htm [Date of use: Feb.4]
- RAO, R & SQILAGI, J.J. 1998. The coming evolution of hedge fund industry. RR Capital Management Corp. and KPMG Consulting. p.17 – 32. Mar.
- REECH, C. 2004. Valuations and risk management: A concept which requires evolution and calibration. *AIMA Journal.* 61:7, Apr.
- RUTTER ASSOCIATES. 2000. Sound practices for hedge fund managers. New York:Wiley. 27p.
- SA HEDGE FUND. 2003. Hedge fund strategies. [Internet:] http://www.sahedgefund.co.za/fund_strategies.htm [Date of use: Nov. 12]
- SAMUELSON, P. 2005. Hedge fund demand to grow 30% in '05. *The Khaleej Times,* [Internet:]

http://www.khaleejtimes.com/Displayarticle.asp?section=business&xfile=data/business/2005/march/business_march106.xml [Date of use: Mar. 5]

- SCHACHTER, B. 2003. The dilemmas of risk disclosure. *Risk special report: Risk management for investors,* p. S2-S6, Sep.

- SCOTT, G. & ZEMCIKY, P. 2002. Can beta-pricing models explain performance differences among assets? [Internet:] http://www.siu.edu/~gilbert/beta.pdf [Date of use: Jan. 14]

- SHAMES, K. 2004. Private communication. *Peregrine Incubator Management.*

- SHARPE, W. F. 1988. Determining a fund's effective asset mix. *Investment management review,* 2(6):59-69, Dec.

- SHARPE, W. F. 1994. The Sharpe Ratio. *The journal of portfolio management,* p. 49-58, Fall.

- SHEWER, K., GOODMAN, M. & HORWITZ, R. 2003. Building a risk-efficient portfolio. *Risk*, 4:12, Apr.

- SOUTH AFRICA. FSB. 2002. Hedge funds and the South African long-term insurance industry. *FSB*. 8p. (LT/01/2003/004)

- SOUTH AFRICA. FSB. 2004. The regulatory position of hedge funds in South Africa - a joint discussion paper. *Hedge funds: Proposed regulatory approach*, p. 1 – 41, Nov.

- STAUM, J. 2002. Simulation in financial engineering. [Internet:] http://www.informs-cs.org/wsc02papers/203.pdf [Date of use: Mar. 2]

- TALJARD, G. 2004. Private communication. *Old mutual asset management.*

- THE ECONOMIST. 2004. Hedge funds: from alpha to omega. p. 71-72, Jul.

- THE ECONOMIST. 2005. Special report: Hedge fund. p.73, Feb.

- UMUT, C., JARROW, R. A. & PROTTER, P. 2004. Liquidity risk and arbitrage pricing theory. *Finance and stochastics*, 8:311-341.

- VAN HEDGE FUND ADVISORS INTERNATIONAL. 2000. Quantitative analysis of hedge fund return/Risk characteristics. Articles on investing in hedge funds. [Internet:] http:www.vanhedge.com/quantit.htm [Date of use: Jun.13].

- VAN HEDGE FUND ADVISORS INTERNATIONAL. 2002. Quantitative analysis of hedge fund return/Risk characteristics. Articles on investing in hedge funds. [Internet:] http://www.hedgefund.com/abouthfs/articles/bookchpt.pdf [Date of use: Jan.13].

- VAN VEEN, M. 2005. Private communication. *Old mutual asset management.*

- VAN VUUREN, G.W. 2005. Private communication. *Merrill Lynch Investment*

Bank.

- VAN VUUREN, G.W. 2005. Private communication. *Old mutual asset management.*

- VAN VUUREN, G.W., BOTHA, M. & STYGER, P. 2000. Effects of a changing Lambda. *South Africa: A Risk special report, Risk supplement*, p. 22–25, Jun.

- WEISSTERIN, E. 1999. Sharpe Ratio. *Mathworld.* [Internet:] http://mathworld.wolfram.com/SharpeRatio.html [Date of use: Sep. 8]

- WIKRAMARATNA, R. 2000. Pseudo-random number generation for parallel Monte Carlo - A splitting approach. [Internet:] http://www.siam.org/siamnews/11-00/splitting.pdf [Date of use: Mar. 4]

- WILMOTT, P. 1998. Derivatives: The theory and practice of financial engineering. London: Wiley. 224p.

- YIELDCURVE.COM. 2003. An introduction to Value-at-Risk. [Internet:] http://www.yieldcurve.com/Mktresearch/LearningCurve/LearningCurve3.pdf [Date of use: Sep. 3]