Chapter 1

Introduction

1.1 Problem description

Investors seek to maximise returns and to minimise risk. As risk is manageable but returns are not, these objectives can best be achieved through risk measurement/management techniques. In this regard, the concept of diversification plays a central role in modern portfolio theory. It follows that investors' welfare can be improved by allocating wealth among a large number of different assets. Ideally, any poorly performing asset can eventually be compensated by for positive performance from other assets in the portfolio. To put it differently, the idiosyncratic risk of a single asset can be diversified away leading to lower portfolio risk and thus a higher risk adjusted portfolio return. Obviously, a necessary condition for risk diversification to work is that asset returns do not depend on each other. Under the assumption of normally distributed returns, a standard assumption in finance, risk and dependence can be expressed by volatility and correlation respectively.

Low volatility and low correlation with other assets offers diversification benefits to investors. These two features, together with historically good performance may explain the increasing attractiveness of hedge funds among institutional and retail investors in recent years. In the last decade the hedge fund industry has been the fastest growing asset class in the financial sector. Despite the decade-long bull market in the 1990s and liquidity/credit crises in the late 1990s, hedge fund investing has been gaining popularity among various types of investors. HFR (2007) estimates that the total net assets in hedge funds are approximately USD 1.4 trillion as of the fourth quarter 2006.

As a result of this growth, an increasing number of studies describing the various hedge fund characteristics, performance comparison with other asset classes, and their overall contribution in institutional portfolios has been produced. Some of the early works are the monographs of Lederman and Klein (1995), Crerend (1998), Jaffer (1998), Lake (1999) as well as the studies of Ackermann, McEnally, and Ravenscraft (1999) and Fung and Hsieh (1997). Other monographs such as Jaffer (2003) focus entirely on the properties of fund of hedge funds.

The risk and diversification benefits of hedge funds have been studied in many different ways. Two major events at the end of 1990s; the near collapse of Long-Term Capital Management and the Asian crisis, have led regulatory authorities to focus more on studying the risk inherent in hedge fund strategies. Brown, Goetzmann, and Park (1998) examine the involvement of hedge funds in the Asian crisis of 1997-1998, and the Report of the President's Working Group on Financial Markets (1999) deals extensively with the Long-Term Capital Management incident in 1998 and highlights the potential risks of excessive use of leverage. The general role played by hedge funds in financial market dynamics has been studied in Eichengreen, Mathieson, Sharma, Chadha, Kodres, and Jansen (1998).

The investment risk of hedge funds, their unique risk properties stand alone as well as in portfolio context have been analysed with standard risk management tools typically assuming implicitly or explicitly normally distributed returns. For example, Edwards and Liew (1999) show that adding hedge funds to traditional portfolios increases the Sharpe ratio of those portfolios. Purcell and Crowley (1999) show that hedge funds outperform traditional assets in times of down markets. Diversification benefits of adding hedge funds are also found in Crerend (1998) and Agarwal and Naik (2000) as well as in Géhin and Vaissié (2005). In these studies a significant upward shift of efficient frontier and reduction in risk measures is observed.

However, hedge funds pose a challenge to standard risk measures based on normally distributed returns. Recent evidence (see e.g. Schmidhuber and Moix 2001, Brooks and Kat 2002) casts doubt on the validity of volatility and correlation as appropriate risk measures for hedge funds. Indeed, the returns of hedge fund indices are not normally distributed and have exhibited unusual levels of skewness and kurtosis. The asymmetric properties of hedge fund returns are investigated in Anson (2002a), Ineichen and Johansen (2002), and Ineichen (2002). These characteristics are consistent with the complex trading strategies used by hedge funds which present option-like payoffs (see e.g. Fung and Hsieh 1997, Fung and Hsieh 2001, Mitchel and Pulvino 2001, Fung and Hsieh 2002c, Agarwal, Fung, Loon, and Naik 2004).

Clearly, volatility and correlation do not provide sufficient information about risk and dependence when the normality assumption is violated. As a consequence, applying symmetric measures on hedge funds may lead to erroneous conclusions. One potential solution to overcome the problem of non-normality in hedge fund returns is to apply methods that take the asymmetry in return distribution into account. For instance, Bacmann and Pache (2004) apply downside deviation, Keating and Shadwick (2002) make use of the Omega function and Favre and Signer (2002) propose the use of a modified Value-at-Risk based on Cornish-Fisher expansion.

In this thesis, the use of *Extreme Value Theory* (EVT) is advocated. This area of statistics enables the estimation of tail probabilities regardless of the underlying distribution of hedge fund returns. The fact that it focuses on the tail returns rather than their means, makes modelling of the whole time series of returns unnecessary. Consequently, the estimation of Value-at-Risk and Expected Shortfall can be done under fairly general types of distributions.

This thesis contributes to the growing literature on risk associated with hedge funds in two main directions. Firstly, it carefully examines the tail risk of individual hedge fund strategies and of portfolios built with stocks, bonds and hedge funds using EVT. Consequently, the first objective is to evaluate the size of return asymmetry in order to quantify a potential tendency for extreme losses among various hedge fund strategies. The second objective follows the first one as it attempts to quantify eventual benefits of the inclusion of hedge funds in a traditional portfolio (stocks and bonds) depending on the initial composition of the portfolio and on the type of hedge funds added. Several papers (Lhabitant 2001, Blum, Dacorogna, and Jaeger 2003, Gupta and Liang 2003) have already used Value-at-Risk derived from EVT in the context of single funds or hedge fund indices. Bacmann and Gawron (2005) evaluates portfolio risk by allocating fund of hedge funds only.

Secondly, the thesis further measures the dependence between hedge funds and traditional investments in periods of distressed markets. In such periods, correlation breaks down and investors' ability to diversify diminishes because the asset dependence is much higher than in periods of market quiescence. For this purpose the main objective is to test explicitly the existence of asymptotic dependence among hedge funds as well as between hedge funds and traditional investments.

1.2 Disposition

This work is organised as follows: Chapter 2 introduces risk measurement techniques especially for assessing risks for non-normal return series; Chapter 3 reviews statistical methods (e.g. EVT) for measuring risk and dependence for asymmetric return distributions; Chapter 4 covers specific characteristics of hedge funds that distinguish them from traditional investments as well as reasons for their asymmetric return distribution; Chapter 5 empirically examines tail properties of hedge funds and compares them with traditional investments; Chapter 6 analyses how hedge funds, stocks and bonds fit together with respect to tail risk; Chapter 7 examines dependence in the tails between hedge funds and traditional investments is examined in Chapter 7; and finally Chapter 8 summarises the thesis conclusions.

Chapter 2

The notion of risk

Since this chapter is concerned with formal financial theory, a general summary of some of the basic ideas in risk management is presented. With this foundation, the discussion of Value-at-Risk and Expected Shortfall in analysing hedge funds becomes more meaningful and clear.

2.1 Risk measurement

Describing risk is a particularly difficult task as no commonly accepted definition exists. In the financial community, risk is usually viewed as exposure to uncertainty or the danger posed to future outcomes by a decision made today. In order to quantify this uncertainty, the different possible outcomes are associated to specific probabilities. Analysing the whole range of probabilities, i.e. probability distribution, is not feasible in practice. This is why simple statistical measures are used to assess the magnitude of risk. The most widely used measure to achieve this task has been the variance (or standard deviation) of returns. Variance describes the variability of returns or dispersion of returns around their mean return. Thus, the higher the variance, the more uncertain the return, and therefore the greater the risk. The vast popularity of variance is largely due to the impact of Modern Portfolio Theory on finance, which dates back to the seminal paper of Markowitz (1952). This theory explores how risk averse investors construct portfolios in order to optimise expected returns for a given level of market risk, from a mean-variance framework. In this regard, this approach views risk as the uncertainty of an investment decision.[1] Nevertheless, the introduction of the mean-variance approach has had significant implications on the development of theory and practice in finance, including that on risk measurement related to the uncertainty of capital requirement decisions. One of these implications is the consideration of distributional assumptions in measuring risk, which is briefly presented below.

Let X denote a random variable, which represents a quantity whose outcome is uncertain. The distribution of X is defined by the probabilities of all events which depend on X. This probability distribution is uniquely specified by the (cumulative) probability distribution function.[2]

$$F(x) = P(X \leq x), \quad -\infty < x < \infty. \tag{2.1}$$

If $F(x)$ is a continuous function of x whose first derivative exists and is continuous, then $F(x)$ can be written as

$$F(x) = \int_{-\infty}^{x} f(t)dt \tag{2.2}$$

where $f(x)$ is called the probability density function of the random variable X and t is used as the variable of integration. A distribution function $F(x)$ is often represented by moments that characterise its main features. Thus, the rth moment of X (or of the distribution of X) is defined by

$$E[X^r] = \int_{-\infty}^{\infty} x^r f(x)dx. \tag{2.3}$$

The first moment is the mean or expected value which specifies the location of the centre of the distribution and it is often denoted by μ. Its central moment of order r is defined as

$$\mu_r = E[(X-\mu)^r] = \int_{-\infty}^{\infty} (x-\mu)^r f(x)dx. \tag{2.4}$$

Hence, μ_2 is the variance which measures the dispersion around the mean of X. The positive square root of variance is called the standard deviation of

[1]See for example the monograph of Moix (2001) for a thorough discussion of these issues.

[2]See Medenhall, Wackerly, and Scheaffer (1990) or any other standard text on statistics for the properties of $F(x)$.

X. Its third and fourth moments are skewness and kurtosis. The former is a measure of asymmetry in the distribution whereas the latter describes the shape of the distribution. A useful distribution often applied in finance is the normal (Gaussian) distribution. It is a bell-shaped distribution which is symmetric with respect to its mean. As this distribution is fully described by its first and second moments, its variance is the adequate measure of risk. Hence, the appropriateness of variance as a risk measure depends strongly on the degree of non-normality of the returns data.[3]

A cornerstone in the mean-variance approach is the quantification of diversification benefits. Markowitz (1952) shows that in attempts to reduce portfolio risk (variance), investors must avoid investing in securities with high covariances among themselves. This means that measuring the degree of dependence between securities is crucial in determining the magnitude of risk where more than one asset is involved. Consequently, in addition to the first two moments of each asset, to construct a properly diversified portfolio, Markowitz's model also requires the expected correlation of each component with every other component. Correlation is a standardised covariance that traditionally has served as a measure of dependence. It is obvious that correlation is strongly related to the variance of the individual assets. Thus, its adequacy as a measure of dependence must be evaluated under the same assumptions as those of variance.

Critics of variance point out that it implies the same sensitivity in both upside and downside movements in return, while investors only dislike downside movements. This very strong assumption has been challenged by the emergence of the Prospect Theory (Kahnemann and Tversky 1979). In that framework, the investor is more affected by a drop in his wealth than by an increase. Moreover, there is strong empirical evidence that asset returns are not symmetric around the mean which rules out the normality assumption. This evidence goes back to Mandelbrot (1963), who argued that volatility

[3] Besides the normality assumption, a second justification for the use of variance as a risk measure comes from the Markowitz (1952) approach. It is well known that this approach is appropriate for investors having quadratic preferences. In that case, investors' expected utility is only a function of the first two moments of the distribution, and thus the variance is the adequate measure of risk.