PART

Eight

Investment Risk Management

CHAPTER 29

Portfolio Risk Management

We now turn to risk management in the context of the portfolio management process. Investors assume risk because they expect to be compensated for it in the form of higher returns. The real issue is how to balance risk against expected return. This trade-off is the subject of **portfolio management**. This requires formal risk measurement, however.

In recent years, institutional investors have placed a much sharper focus on the total risk of their portfolio. This has led to the widespread use of **risk budgeting**. The process starts with a broad portfolio allocation into asset classes that reflects the best trade-off between risk and return. Once a total risk budget is decided upon, this can be allocated to various asset classes and managers. Thus, risk budgeting reflects a top-down view of the total portfolio risk.

At the end of the investment process, it is important to assess whether realized returns were in line with the risks assumed. The purpose of **performance evaluation** methods is to decompose the investment performance into various components. The goal is to identify whether the active manager really adds value. Part of the returns generally represents general market factors, also called "beta bets"; the remainder represents true value added, or "alpha bets."

The purpose of this chapter is to present risk and performance evaluation tools used in the investment management industry. Section 29.1 gives a brief introduction to institutional investors. Performance evaluation techniques are developed in Section 29.2. Finally, Section 29.3 discusses risk budgeting. Hedge funds, because of their importance, will be covered in the next chapter.

29.1 INSTITUTIONAL INVESTORS

Institutional investors are entities that have large amounts of funds to invest for an organization, or on behalf of others. This is in contrast with *private* investors.[1] As shown in Table 29.1, institutional investors can be classified into investment companies, pension funds, insurance funds, and others. The latter category includes endowment funds, bank-managed funds, and private partnerships, also known as

FRM Exam Part 2 topic.

[1] The Securities and Exchange Commission (SEC) has formal definitions of, for example, qualified institutional buyers under Rule 144a.

TABLE 29.1 Classification of Institutional Investors

Investment companies	Open-end funds Closed-end funds
Pension funds	Defined benefit Defined contribution
Insurance funds	Life Nonlife
Others	Foundations and endowment funds Nonpension funds managed by banks Private partnerships

hedge funds. **Hedge funds** are private partnership funds that can take long and short positions in various markets and are accessible only to large investors.

Even though institutional investors and bank proprietary desks are generally exposed to similar risk factors, their philosophies are quite different. Bank trading desks employ high leverage and are aggressive investors. They typically have short horizons and engage in active trading in generally liquid markets. Financial institutions, such as commercial banks, investment banks, and broker-dealers, are sometimes called the **sell side** because they are primarily geared toward selling financial services.

Institutional investors are part of the **buy side** because they are buying financial services from the sell side, in other words Wall Street for the United States. In contrast to the sell side, institutional investors have little or no leverage and are more conservative. Most have longer time horizons and can invest in less liquid markets. Many hedge funds, however, have greater leverage and trade actively.

29.2 PERFORMANCE EVALUATION

Performance evaluation is the process by which investment management decisions are measured and assessed. It can be broken down into three steps.

1. **Performance measurement** starts with the computation of total return, which is then compared to the **benchmark** in terms of total and relative risk.
2. **Performance attribution** decomposes the performance of a portfolio and its benchmark to sources of differential returns. This typically includes asset allocation, currency selection, industry selection, and security selection. Risk is also attributed to these factors.
3. **Performance appraisal** is the evaluation of risk-adjusted performance and investment skill. This involves making a judgment as to whether the outperformance is due to luck or to skill.

Performance measurement should properly adjust for the risks taken. This can be done with a number of metrics, typically based on the standard deviation and regression coefficients. At an even more basic level, however, the first question is how to define the risks that matter to the investor or the manager. In particular, should risk be measured in absolute terms or relative to some benchmark?

29.2.1 Return Measurement

The first step of performance evaluation is the proper measurement of periodic returns. This is not always obvious due to the fact that a portfolio's value is affected by cash inflows and outflows, which are outside the control of the investment manager. By now, the industry standard is the **time-weighted rate of return** (TWRR). This method involves valuing the portfolio on a regular basis, and certainly before cash flows. Returns are then linked by compounding over the period. Assume, for instance, that R_t is the daily return. The monthly return is then over T days

$$(1 + R) = [(1 + R_1)(1 + R_2) \dots (1 + R_T)] \tag{29.1}$$

The TWRR method provides a measure of performance that is not sensitive to the timing or amount of cash flows.[2]

29.2.2 Risk Measurement

Next, risk can be measured from returns or from positions. As in Chapter 1, we can take two views of risk. Let us use the standard deviation as the risk measure, as an example.

- **Absolute risk** is measured in terms of shortfall relative to the initial value of the investment, or perhaps an investment in cash. Let us use the standard deviation as the risk measure and define P as the initial portfolio value and R_P as the rate of return. Absolute risk in dollar terms is

$$\sigma(\Delta P) = \sigma(\Delta P/P) \times P = \sigma(R_P) \times P \tag{29.2}$$

- **Relative risk** is measured relative to a benchmark index and represents active management risk. Defining B as the benchmark, the deviation is $e = R_P - R_B$, which is also known as the **tracking error**. In dollar terms, this is $e \times P$. The risk is

$$\sigma(e)P = [\sigma(R_P - R_B)] \times P = [\sigma(\Delta P/P - \Delta B/B)] \times P = \omega \times P \tag{29.3}$$

  where ω is called **tracking error volatility** (TEV), or sometimes **active risk**. Defining σ_P and σ_B as the volatility of the portfolio and the benchmark and ρ as their correlation, the variance of the difference is

$$\omega^2 = \sigma_P^2 - 2\rho\sigma_P\sigma_B + \sigma_B^2 \tag{29.4}$$

Consider the example of a fund with volatility of $\sigma_P = 22\%$. This fund is compared to a benchmark with volatility of $\sigma_B = 20\%$, to which the correlation is $\rho = 0.9864$. What is the tracking error volatility? Using Equation

[2] This method differs from the **money-weighted rate of return** (MWRR), which is the internal rate of return on a portfolio taking into account all cash flows. This is similar to a yield to maturity on a bond and is easy to compute. The MWRR method, however, does not revalue the portfolio at intermediate steps and hence provides performance numbers that depend on the timing and size of cash flows. As such, it is considered inferior to the TWRR.

(29.4), we have $\omega^2 = 22\%^2 - 2 \times 0.9864 \times 22\% \times 20\% + 20\%^2 = 0.0016$, giving $\omega = 4.0\%$. Thus the tracking error is much smaller than the absolute risk. This is due to the fact that the portfolio is highly correlated with the benchmark. If the correlation were zero, ω would be 30%.

One of the advantages of focusing on relative risk is that tests of outperformance are more powerful because the volatility measure is lower. Assume, for example, that the portfolio returns 4% in excess of the benchmark, and 9% in excess of cash, all in percent per annum. After $T = 4$ years, we can compute a t-statistic for the hypothesis that the active manager adds no value, or that any outperformance is due to luck. The statistic is

$$\frac{(\bar{R}_P - \bar{R}_B)}{(\omega/\sqrt{T})} = \frac{(4\%)}{(4\%/\sqrt{4})} = \frac{4\%}{2\%} = 2.0$$

Because this is greater than 1.96, we can reject the null hypothesis. However the same computation using absolute returns gives $t = 0.82$, in which case we cannot reject the null hypothesis. Thus, we can conclude that the manager has skill when using relative returns but not when using absolute returns.

Also note that the t-statistic is a simple transformation of the information ratio[3]

$$t = \frac{(\bar{R}_P - \bar{R}_B)}{(\omega/\sqrt{T})} = \frac{(\bar{R}_P - \bar{R}_B)}{\omega}\sqrt{T} = \text{IR}\sqrt{T} \tag{29.5}$$

Using absolute or relative risk depends on how the trading or investment operation is judged. For bank trading portfolios or hedge funds, market risk is measured in absolute terms. These are sometimes called **total return funds**. In contrast portfolio managers that are given the task of beating a benchmark or peer group measure risk in relative terms.

EXAMPLE 29.1: FRM EXAM 2008—QUESTION 5-9

Over the past year, the HIR Fund had a return of 7.8%, while its benchmark, the S&P 500 index, had a return of 7.2%. Over this period, the fund's volatility was 11.3%, while the S&P index's volatility was 10.7% and the fund's TEV was 1.25%. Assume a risk-free rate of 3%. What is the information ratio for the HIR Fund and for how many years must this performance persist to be statistically significant at a 95% confidence level?

a. 0.480 and approximately 16.7 years
b. 0.425 and approximately 21.3 years
c. 3.840 and approximately 0.2 years
d. 1.200 and approximately 1.9 years

[3] This was defined in Chapter 1 and will be reviewed in the next section.

29.2.3 Surplus Risk

As is sometimes said, "risk is in the eye of the beholder." For investors with fixed future liabilities, the risk is not being able to perform on these liabilities. For pension funds with **defined benefits**, these liabilities consist of promised payments to current and future pensioners, and are called **defined benefit obligations**. In this case, the investment risk falls on the entity promising the benefits. In contrast, employees covered by a **defined contribution** plan are subject to investment risk.

For life insurance companies, these liabilities represent the likely pattern of future claim payments. These liabilities can be represented by their net present value. In general, the present value of long-term fixed payments behaves very much like a *short position in a fixed-rate bond*. If the payments are indexed to inflation, the analogous instrument is an inflation-protected bond.

The difference between the current values of assets and liabilities is called the **surplus**, S, defined as the difference between the value of assets A and liabilities L. The change is then $\Delta S = \Delta A - \Delta L$. Normalizing by the initial value of assets, we have

$$R_S = \frac{\Delta S}{A} = \frac{\Delta A}{A} - \frac{\Delta L}{L}\frac{L}{A} = R_{\text{assets}} - R_{\text{liabilities}}\frac{L}{A} \tag{29.6}$$

The duration of liabilities is long, typically 12 years. Using the duration approximation, the return on liabilities can be measured from changes in yields y, as $R_{\text{liabilities}} = -D^*\Delta y$. The worst combination of movements in market values is when assets fall due to a fall in equities, in a year when yields decrease. **Immunization** occurs when the asset portfolio, or part of it, provides a perfect hedge against changes in the value of the liabilities. Thus, investments in long-term bonds help to hedge movements in liabilities.

In this case, risk should be measured as the potential shortfall in surplus over the horizon. This is sometimes called **surplus at risk**. This value at risk (VAR)-type measure is an application of relative risk, where the benchmark is the present value of liabilities.

EXAMPLE 29.2: PENSION FUND LIABILITIES

The AT&T pension plan reports a projected benefit obligation of $17.4 billion. If the discount rate decreases by 0.5%, this liability will increase by $0.8 billion. Based on this information, the liabilities behave like a

a. Short position in the stock market
b. Short position in cash
c. Short position in a bond with maturity of about nine years
d. Short position in a bond with duration of about nine years

EXAMPLE 29.3: PENSION FUND RISK

The AT&T pension fund reports total assets worth $19.6 billion and liabilities of $17.4 billion. Assume the surplus has a normal distribution and volatility of 10% per annum. The 95% surplus at risk over the next year is

a. $360 million
b. $513 million
c. $2,860 million
d. $3,220 million

EXAMPLE 29.4: FRM EXAM 2006—QUESTION 25

The DataSoft Corporation has an employee pension scheme with fixed liabilities and a long time horizon reflecting its young workforce. The fund's assets are $9 billion and the present value of its liabilities is $8.8 billion. Which of the following statements are *incorrect*?

I. The present value of long-term fixed payments behaves very much like a long position in a fixed-rate bond.
II. Surplus at risk is a measure of relative risk.
III. The DataSoft Corporation will be able to immunize its liabilities by investing $8 billion in long-term fixed-rate bonds.

a. I and II
b. II and III
c. I and III
d. I, II and III

29.2.4 Returns-Based and Position-Based Risk Measures

Traditionally, risk has been measured from returns-based information, i.e. (from the time series of historical returns on the portfolio $R_{P,t}$). On the one hand, a returns-based risk system is easy and cheap to implement. On the other hand, returns-based measures suffer from severe drawbacks. They are ineffective for new instruments, markets, and managers because there is no history. They do not capture **style drift**, which is the divergence of a portfolio manager from its stated investment style. They may not reveal hidden risks such as out-of-the-money short positions in options. Such positions capture a stable premium but may not reveal the occurrence of a big loss.

Most of these drawbacks are addressed by position-based risk measures. They can be applied to new instruments, markets, and managers. These use the most current position information, which should reveal style drift or hidden risks.

Position-based risk systems, however, can be challenging to implement and have drawbacks that risk managers must understand. First, they require more resources and are expensive to implement. A large bank could have several million positions, in which case aggregation at the top level is a major technology challenge. Second, position-based risk measures assume that the portfolio is frozen over the time horizon considered, thus ignoring any active trading that takes place in practice. Finally, position-based systems are susceptible to errors and approximations in data and models. They require modeling all positions from the ground up, repricing instruments as a function of movements in the risk factors. The modeling of some instruments can be complex, leading to model risk.

Even so, position-based risk measures are vastly more informative than returns-based risk measures. This explains why modern risk management systems are built from position-level information.

29.2.5 Risk-Adjusted Performance Measurement

This dichotomy, absolute versus relative returns, carries through performance measurement, which evaluates the risk-adjusted performance of the fund. The **Sharpe ratio** (SR) measures the ratio of the average rate of return, $\mu(R_P)$, in excess of the risk-free rate R_F, to the absolute risk

$$\text{SR} = \frac{[\mu(R_P) - R_F]}{\sigma(R_P)} \tag{29.7}$$

The Sharpe ratio focuses on total risk measured in absolute terms. Because total risk includes both systematic and idiosyncratic risk, this measure is appropriate for portfolios that are not very diversified (i.e., that have large idiosyncratic risk).

A related measure is the **Sortino ratio** (SOR). This replaces the standard deviation in the denominator by the semistandard deviation, $\sigma_L(R_P)$, which considers only data points that represent a loss. The ratio is

$$\text{SOR} = \frac{[\mu(R_P) - R_F]}{\sigma_L(R_P)} \tag{29.8}$$

where $\sigma_L(R_P) = \sqrt{\frac{1}{(N_L)} \sum_{i=1}^{N} [\text{Min}(R_{P,i}, 0)]^2}$, and N_L is the number of observed losses. The Sortino ratio is more relevant than the Sharpe ratio when the return distribution is skewed to the left. It is much less widely used, however.

In contrast, the **information ratio** (IR) measures the ratio of the average rate of return in excess of the benchmark to the TEV

$$\text{IR} = \frac{[\mu(R_P) - \mu(R_B)]}{\omega} \tag{29.9}$$

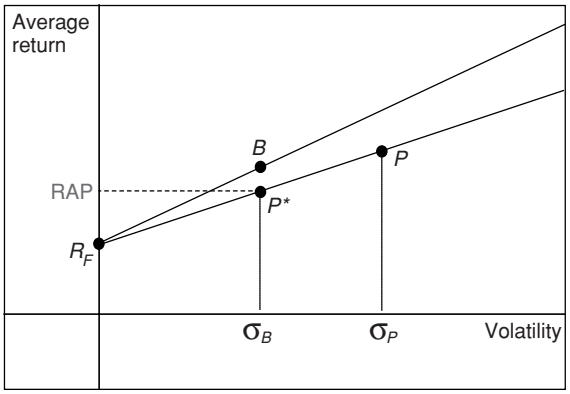

FIGURE 29.1 Risk-Adjusted Performance

Dealing with ratios, however, is rather abstract. It is more intuitive to express performance in terms of a rate of return, adjusted for risk. Suppose we use a reference benchmark, R_B, for which we measure first its average return and risk. We can leverage up or down the portfolio P so as to bring its volatility in line with B. The **risk-adjusted performance** (RAP) is then[4]

$$\text{RAP}_P = R_F + \frac{\sigma_B}{\sigma_P}[\mu(R_P) - R_F] \tag{29.10}$$

This is illustrated in Figure 29.1. The average return on portfolio P is greater than that of B. Its volatility, however, is much higher. The straight line going from R_F to R_P represents portfolios that mix the risk-free asset with P. For example, an investment of 50% in each will give an average return that is the mean of R_F and $\mu(R_P)$, and a volatility that is half that of P. The slope of this line represents the Sharpe ratio, given by Equation (29.7).

Portfolio P^* has the same level of risk as B; its performance is given by Equation (29.10). We can then compare directly RAP_P and $\mu(R_B)$. In this case, portfolio P underperforms B on a risk-adjusted basis. We obtain the same ranking between P and B, however, using the Sharpe ratio.

EXAMPLE 29.5: FRM EXAM 2009—QUESTION 8-2

Your firm hired Vikram Mehra as an active manager for its pension fund. His benchmark is the Russell 2000 growth index. Which of the following statistics are most suitable to evaluating Vikram's performance and risk?

a. VAR and Sharpe ratio
b. Tracking error and information ratio
c. Tracking error and Sharpe ratio
d. VAR and information ratio

[4] This performance measure is sometimes called *M*-square.

29.2.6 Performance Attribution: Returns-Based

So far, we have implemented a simple adjustment for risk that takes into account a volatility measure. To evaluate the performance of investment managers, however, it is crucial to decompose the total return into a component due to market risk premiums and to other factors. Exposure to the stock market is widely believed to reward investors with a long-term premium, called the **equity premium**. Assume that this premium is EP = 4 % annually. This is the expected return in excess of the risk-free rate. For simplicity, it is usually assumed that the same rate applies to lending and borrowing.

Now take the example of an investment fund of $1 million. A long position of $1.5 million, or 150% in passive equities financed by 50% cash borrowing, should have an *excess return* composed of the total return on the 150% equity position, minus the cost of borrowing 50%, minus the risk-free rate. This gives

$$[150\% \times (\text{EP} + R_F) - 50\% R_F] - R_F = 1.5 \times \text{EP} = 6\%$$

This could be also achieved by taking a notional position of $1.5 million in stock index futures and parking the investment in cash, including the margin. So, an investment manager who returns 6% in excess of the risk-free rate in this way is not really delivering any value added because this extra amount is simply due to exposure to the market. Therefore, it is crucial to account for factors that are known to generate risk premiums.

Define $R_{M,t}$ as the rate of return in period t on the stock market, say the S&P 500 for U.S. equities; define $R_{F,t}$ as the risk-free rate; and $R_{P,t}$ is the return on the portfolio. The general specification for this adjustment consists of estimating the regression

$$R_{P,t} - R_{F,t} = \alpha_P + \beta_P [R_{M,t} - R_{F,t}] + \epsilon_{P,t}, \quad t = 1, \ldots, T \tag{29.11}$$

where β_P is the exposure of portfolio P to the market factor, or **systematic risk**, and α_P is the abnormal performance after taking into account the exposure to the market. The intercept is also known as **Jensen's alpha**. This term is widely used in the investment management industry to describe the performance adjusted for market factors.

Denoting $\bar{R} = (1/T) \sum_{t=1}^{T} (R_t - R_{F,t})$ as the average over the sample period, the estimated alpha is

$$\widehat{\alpha} = \bar{R} - \widehat{\beta} \bar{R}_M \tag{29.12}$$

If there is no exposure to the market ($\beta = 0$), Equation (29.12) shows that alpha is the sample average of the investment returns. More generally, Equation (29.12) properly accounts for the exposure to the systematic risk factor. In the case of our investment fund, we have $\bar{R} = 6\%$, and $\beta = 1.5$. So, the alpha is

$$\widehat{\alpha} = 6\% - 1.5 \times 4\% = 0$$

which correctly indicates that there is no value added.

KEY CONCEPT

Performance evaluation must take into account the component of returns that can be attributed to exposures on general market factors (or risk premiums). An investment manager adds value only if the residual return, called alpha, is positive.

This specification can be generalized to multiple factors. Assume we believe that in addition to the market premium, a premium is earned for *value* (or for low price-to-book companies) and *size* (or for small firms). We need to take this information into account in evaluating the manager; otherwise he or she may load up on factors that are priced but not recorded in the performance attribution system. With K factors, Equation (29.11) can be generalized to

$$R_i = \alpha_i + \beta_{i1} y_1 + \cdots + \beta_{iK} y_K + \epsilon_i \tag{29.13}$$

This decomposition is also useful to detect **timing ability**, which consists of adding value by changing exposures on risk factors. A manager could, for example, move into stocks with higher betas in anticipation of the market going up. Timing ability can be detected by adding another term to Equation (29.11):

$$R_{P,t} - R_{F,t} = \alpha_P + \beta_P [R_{M,t} - R_{F,t}] + \delta_P [R_{M,t} - R_{F,t}] D_t + \epsilon_{P,t} \tag{29.14}$$

where D_t is a dummy variable that is equal to $D_t = +1$ for up markets and $D_t = 0$ for down markets. A positive coefficient δ_P indicates that the manager has added value from market timing, implying that beta is positively correlated with the market.

Another popular tool is **style analysis**.[5] The objective is to explain the fund returns by predefined asset classes, $F_1, F_2, \ldots, F_K$. These could be, for instance, (1) large U.S. stocks, (2) small U.S. stocks, and (3) international stocks. We then run a regression on these three factors:

$$R_i = \beta_{i1} F_1 + \beta_{i2} F_2 + \beta_{i3} F_3 + \epsilon_i \tag{29.15}$$

This should be set up in a way that constrains the estimated coefficients to be positive $\beta \geq 0$ and to add up to one, $\beta_{i1} + \beta_{i2} + \beta_{i3} = 1$. Here, the exposures can be interpreted as weights on the asset classes. This identifies the combination of long positions in passive indices that would have most closely replicated the actual performance of the fund. For example, suppose the regression yields weights of 25%, 25%, and 50%, with an R-squared of 92%. In other words, this passive allocation to three indices was associated with 92% of the return variance, with the remainder due to other factors. This is useful to understand the drivers of the

[5] W. Sharpe, "Asset Allocation: Management Style and Performance Measurement," *Journal of Portfolio Management* 18 (1992): 7–19.

performance of the portfolio. In addition, these weights could be used to construct a benchmark to which future portfolio performance can be compared.

Finally, consider the effect of leverage on the portfolio. Long leverage is the ratio of assets to equity. For instance, a fund may have $100 million in investors' money, borrow $100 million, and invest $200 million in stocks. The short position (i.e., the loan) has no market risk. In this case, the leverage is 2 to 1. A profit of 10% on the portfolio assets, or $20 million, now represents a 20% return on the equity. Thus, leverage multiplies asset returns to give equity returns. In Equation (29.11), leverage multiplies α_P, β_P, and ϵ_P. From the regression decomposition, $V(R_P) = \beta_P^2 V(R_M) + V(\epsilon_P^2)$. Thus leverage increases proportionately the total volatility σ_P as well as the volatility of the residual $\sigma_{\epsilon,P}$.

EXAMPLE 29.6: FRM EXAM 2008—QUESTION 5-13

Portfolio Q has a beta of 0.7, an expected return of 12.8%, and an equity risk premium of 5.25%. The risk-free rate is 4.85%. Calculate Jensen's alpha measure for portfolio Q.

a. 7.67%
b. 2.70%
c. 5.73%
d. 4.27%

EXAMPLE 29.7: PERFORMANCE EVALUATION

Assume that a hedge fund provides a large positive alpha. The fund can take leveraged long and short positions in stocks. The market went up over the period. Based on this information,

a. If the fund has net positive beta, all of the alpha must come from the market.
b. If the fund has net negative beta, part of the alpha comes from the market.
c. If the fund has net positive beta, part of the alpha comes from the market.
d. If the fund has net negative beta, all of the alpha must come from the market.

29.2.7 Performance Attribution: Position-Based

So far, the analysis has used actual portfolio returns. The performance evaluation process, however, could be deepened by using positions.

Suppose, for example, that we want to understand the performance drivers for a portfolio of global stocks. The fund invests in three asset classes, (1) large U.S. stocks, (2) small U.S. stocks, and (3) international stocks. At the beginning

of the month, the weights w_i are 30%, 30%, and 40%, respectively. We then decompose the return into a component due to a set of passive factor returns and to a specific return

$$R_P = w_{P1}F_1 + w_{P2}F_2 + w_{P3}F_3 + \epsilon_P \tag{29.16}$$

The same analysis can be performed in terms of the active return, which is the portfolio return minus the benchmark return:

$$R_P - R_B = [(w_{P1} - w_{B1})F_1 + (w_{P2} - w_{B2})F_2 + (w_{P3} - w_{B3})F_3] + \epsilon_P \tag{29.17}$$

Here, the term between brackets represents the active return due to the asset allocation decision. For example, a finding that the first term is regularly positive but that the specific term is not would suggest that the manager has skill in asset allocation but not in other decisions for this fund. This type of analysis can be extended to evaluate the value added from country selection, currency selection, and security selection.

29.2.8 Performance Evaluation and Survivorship

Another key issue when evaluating the performance of a group of investment managers is **survivorship**. This occurs when funds are dropped from the investment universe for reasons related to poor performance and survivors only are considered. Commercial databases often give information on funds that are alive only, because clients are no longer interested in dead funds.

The problem is that the average performance of the group of funds under examination becomes subject to **survivorship bias**. In other words, the apparent performance of the existing funds is too high, or biased upward relative to the true performance of the underlying population, due to the omission of some poorly performing funds.

The extent of this bias depends on the attrition rate of the funds and can be very severe. Mutual fund studies, for example, report an **attrition rate** of 3.6% per year. This represents the fraction of funds existing at the beginning of the year that becomes dead during the year. In this sample, the survivorship bias is estimated at approximately 0.70% per annum.[6] This represents the difference between the performance of the survived sample and that of the true population. This is a significant number because it is on the order of management fees, which are around 1% of assets per annum. Samples with higher attrition rates have larger biases. For example, **Commodity Trading Advisors** (CTAs), a category of hedge funds, are reported to have an attrition rate of 16% per year, leading to survivorship biases on the order of 5.2% per annum, which is very high.[7]

Other sources of bias can be introduced, due to the inclusion criteria and the voluntary reporting of returns. A fund with excellent performance is more likely

[6] Mark Carhart, Jennifer Carpenter, Anthony Lynch, and David Musto, "Mutual Fund Survivorship," *Review of Financial Studies* 15 (2002): 1355–1381.

[7] CTAs are investment managers that trade futures and options. In the United States, they are regulated by the Commodity Futures Trading Commission (CFTC).

to be chosen for inclusion by the database vendor, or the investment manager of such a fund may be more inclined to submit the fund returns to the database. Consequently, there is a bias toward adding funds with better returns. Or a fund may decide to stop reporting returns if its performance drops. This is called **selection bias**. This bias differs from the previous one because it also exists when dead funds are included in the sample.

Finally, another subtle bias arises when firms incubate different types of funds before making them available to outsiders. Say 10 different funds are started by the same company over a two-year period. Some will do well and others will not, partly due to chance. The best-performing fund is then opened to the public, with its performance instantly backfilled for the previous two years. The other funds are ignored or disbanded. As a result, the performance of the public fund is not representative of the entire sample. This is called **instant-history bias**. The difference between this bias and selection bias is that the fund was not open to investors during the reported period.

KEY CONCEPT

Performance evaluation can be overly optimistic if based on a sample of funds affected by survivorship, selection, or instant-history bias. The extent of survivorship bias increases with the attrition rate.

EXAMPLE 29.8: FRM EXAM 2005—QUESTION 103

A database of hedge fund returns is constructed as follows. The first year of the database is 1994. All funds existing as of the end of 1994 that a willing to report their verified returns for that year are included in that year. The database is extended by asking the funds for verified returns before 1994. Subsequently, funds are added as they are willing to report verified returns to the database. If a fund stops reporting returns, its returns are deleted from the database, but the database has an agreement with funds that they will keep reporting verified returns even if they stop being open to new investors. Which of the following four statements are correct?

I. The database suffers from backfilling bias.
II. The database suffers from survivorship bias.
III. The database suffers from an errors-in-variables bias.
IV. The equally weighted annual return average of fund returns will underestimate the performance one would expect from a hedge fund.

a. All the above statements are correct.
b. Statements I and II are correct.
c. Statements I, II, and III are correct.
d. Statements II and IV are correct.

29.3 RISK BUDGETING

The revolution in risk management reflects the recognition that risk should be measured at the highest level—that is, firmwide or portfolio-wide. This ability to measure total risk has led to a top-down allocation of risk, called **risk budgeting**. Risk budgeting is the process of parceling out the total risk of the fund, or risk budget, to various assets classes and managers.

This concept is being implemented by institutional investors as a follow-up to their **asset allocation process**. Asset allocation consists of finding the optimal allocation into major asset classes (i.e., the allocation that provides the best risk/return trade-off for the investor). This choice defines the total risk profile of the portfolio.

29.3.1 Illustration

Consider, for instance, an investor having to decide how much to invest in U.S. stocks, in U.S. bonds, and in non-U.S. bonds. Risk is measured in absolute terms, assuming returns have a joint normal distribution. More generally, this could be extended to other distributions or to a historical simulation method. The allocation will depend on the expected return and volatility of each asset class, as well as their correlations. Table 29.2 illustrates these data, which are based on historical dollar returns measured over the period 1978 to 2003.

Say the investor decides that the portfolio with the best risk/return trade-off has an expected return of 12.0% with total risk of 10.3%. Table 29.2 shows a portfolio allocation of 60.0%, 7.7%, and 32.3% to U.S. stocks, U.S. bonds, and non-U.S. bonds, respectively.

The volatility can be measured in terms of a 95% annual VAR. This defines a total risk budget of $\text{VAR} = \alpha\sigma W = 1.645 \times 10.3\% \times \$100 = \$16.9$ million. This VAR budget can then be parceled out to various asset classes and active managers within asset classes.

Risk budgeting is the process by which these efficient portfolio allocations are transformed into VAR assignments. At the asset class level, the individual VARs are \$15.3, \$0.9, and \$5.9 million, respectively. For instance, the VAR budget for U.S. stocks is $60.0\% \times (1.645 \times 15.50\% \times \$100) = \$15.3$ million. Note that the sum of individual VARs is \$22.1 million, which is greater than the portfolio VAR of \$16.9 million due to diversification effects.

TABLE 29.2 Risk Budgeting

Asset		Expected Return	Volatility	Correlations 1	2	3	Percentage Allocation	VAR
U.S. stocks	1	13.80%	15.50%	1.00			60.0	\$15.3
U.S. bonds	2	8.40%	7.40%	0.20	1.00		7.7	\$0.9
Non-U.S. bonds	3	9.60%	11.10%	0.04	0.40	1.00	32.3	\$5.9
Portfolio		12.00%	10.30%				100.0	\$16.9

The process can be repeated at the next level. The fund has a risk budget of \$15.3 million devoted to U.S. equities, with an allocation of \$60 million. This allocation could be split equally between two active equity managers. Assume that the two managers are equally good, with a correlation of returns of 0.5. The optimal risk budget for each is then \$8.83 million. We can verify that the total risk budget is

$$\sqrt{8.83^2 + 8.83^2 + 2 \times 0.5 \times 8.83 \times 8.83} = \sqrt{233.91} = \$15.3$$

Note that, as in the previous step, the sum of the risk budgets, which is \$8.83 + \$8.83 = \$17.66 million, is greater than the total risk budget of \$15.3 million. This is because the latter takes into account diversification effects. If the two managers were perfectly correlated with each other, the risk budget would have to be \$15.3/2 = \$7.65 million for each. This higher risk budget is beneficial for the investor because it creates more opportunities to take advantage of the managers' positive alphas.

The risk budgeting process highlights the importance of correlations across managers. To control their risk better, institutional investors often choose equity managers that follow different market segments or strategies. For example, the first manager could invest in small growth stocks, the second in medium-size value stocks. Or the first manager could follow momentum-based strategies, the second value-based strategies. The first type tends to buy more of a stock after its price has gone up, and the second after the price has become more attractive (i.e., low). Different styles lead to low correlations across managers. For a given total risk budget, low correlations mean that each manager can be assigned a higher risk budget, leading to a greater value added for the fund.

These low correlations explain why investors must watch for **style drift**, which refers to a situation where an investment manager changes investment style. This is a problem for the investor because it can change the total portfolio risk. If all the managers, for instance, drift into the small growth stocks category, the total risk of the fund will increase. Style drift is controlled by the choice of benchmarks with different characteristics, such as small growth and medium value indices, and by controls on the tracking error volatility for each manager.

In conclusion, this risk budgeting approach is spreading rapidly to the field of investment management. This approach provides a consistent measure of risk across all subportfolios. It forces managers and investors to confront squarely the amount of risk they are willing to assume. It gives them tools to monitor their risk in real time.

29.3.2 Marginal Risk and Contribution to Risk

A well-designed risk system should also provide tools to understand how to manage risk. A risk report should display measures of **marginal risk**. This represents

the change in risk due to a small increase in one of the allocations. Using the volatility of returns as the risk measure, this is

$$\text{MRISK} = \frac{\partial \sigma_p}{\partial w_i} = \frac{\text{cov}(R_i, R_p)}{\sigma_P} = \beta_{i,P}\sigma_P \tag{29.18}$$

Thus, beta represents the marginal contribution to the risk of the total portfolio P. A large value for β indicates that a small addition to this position will have a relatively large effect on the portfolio risk. Conversely, positions with large betas should be cut first because they will lead to the greatest reduction in risk. **Marginal VAR** is a similar measure, except that MRISK is multiplied by the α that corresponds to the confidence level.

This can be expanded to measure contributions to the portfolio risk. The **risk contribution**, or **risk allocation**, is obtained by multiplying the marginal risk for position i by its weight i

$$\text{CRISK} = w_i\beta_{i,P}\sigma_P \tag{29.19}$$

Because the beta of a portfolio with itself is one, the sum of $w_i\beta_{i,P}$ is guaranteed to be one. Hence, the sum of the risk contributions adds up exactly to the total portfolio risk, σ_P. When risk is expressed in terms of VAR, this measure is called **component VAR**.

Table 29.3 gives an example, expanding on the previous table. The marginal risk column shows that U.S. stocks are the asset class with the greatest marginal contribution to the risk of the portfolio. As an example, increasing the allocation from 60% to 61% increases the portfolio risk from 10.30% to 10.44%, which is an increase of 0.14%. This is precisely the marginal risk number of 0.14 multiplied by the 1% weight increase.

The last column shows the risk contribution, or allocation. Out of a total portfolio risk of 10.30%, 8.63% is attributed to U.S. stocks. This high number reflects the high volatility of this asset class, its high weight in the portfolio, as well as correlations. Reporting systems should therefore display not only the conventional weights, or market allocations, but also risk allocations.

TABLE 29.3 Risk Analysis

Asset	Volatility	Market Allocation	Marginal Risk	Risk Allocation
U.S. stocks	15.50%	60.0%	0.1438	8.63%
U.S. bonds	7.40%	7.7%	0.0278	0.21%
Non-U.S. bonds	11.10%	32.3%	0.0451	1.46%
Portfolio	10.30%	100.0%		10.30%

Such analysis provides useful insights into the structure of the portfolio. Given a scarce risk budget, high risk allocations can be justified only by expected returns that are high relative to other assets. In fact, an exact relationship holds for portfolios that are mean-variance efficient (i.e., maximize the Sharpe ratio). If this is the case with portfolio P, then the ratio of excess returns on all assets to their marginal risk, which is also proportional to the Treynor ratio, must be the same. However if P is not efficient, then we should be able to improve its performance by tilting toward assets that provide a greater ratio of expected return to their contribution to risk. Thus, this top-down analysis of portfolio risk can help investors improve the performance of their portfolios, given a set of risk measures and asset class forecasts.

EXAMPLE 29.9: RISK BUDGETING

The AT&T pension fund has 68%, or about $13 billion, invested in equities. Assume a normal distribution and volatility of 15% per annum. The fund measures absolute risk with a 95%, one-year VAR, which gives $3.2 billion. The pension plan wants to allocate this risk to two equity managers, each with the same VAR budget. Given that the correlation between managers is 0.5, the VAR budget for each should be

a. $3.2 billion
b. $2.4 billion
c. $1.9 billion
d. $1.6 billion

EXAMPLE 29.10: FRM EXAM 2005—QUESTION 140

Suppose a portfolio consists of four assets. The risk contribution of each asset is as follows: UK large cap, 3.9%; UK small cap, 4.2%; UK bonds, 0.9%; non-UK bonds, 1.1%. Which of the following would *not* be a possible explanation for the relatively high risk contribution values for UK equities?

a. High expected returns on UK equities
b. High weights on UK equities
c. High volatilities of UK equities
d. High correlation of UK equities with all other assets in the portfolio

EXAMPLE 29.11: FRM EXAM 2009—QUESTION 8-9

A risk manager assumes that the joint distribution of returns is multivariate normal and calculates the following risk measures for a two-asset portfolio:

Asset	Position	Individual VAR	Marginal VAR	VAR Contribution
1	USD 100	USD 23.3	0.176	USD 17.6
2	USD 100	USD 46.6	0.440	USD 44.0
Total	USD 200	USD 61.6		USD 62.6

If asset 2 is dropped from the portfolio, what is the reduction in portfolio VAR?

a. USD 15.0
b. USD 38.3
c. USD 44.0
d. USD 46.6

EXAMPLE 29.12: FRM EXAM 2009—QUESTION 8-10

Continue with the previous question. Let $\beta_{ip} = \rho_{ip}\sigma_i/\sigma_p$, where ρ_{ip} denotes the correlation between the return of asset i and the return of the portfolio, σ_i is the volatility of the return of asset i, and σ_p is the volatility of the return of the portfolio. What are β_1 and β_2?

a. $\beta_1 = 0.571$, $\beta_2 = 1.429$
b. $\beta_1 = 0.756$, $\beta_2 = 1.513$
c. $\beta_1 = 0.286$, $\beta_2 = 0.714$
d. Cannot determine from information provided

EXAMPLE 29.13: FRM EXAM 2009—QUESTION 8-12

The pension management analysts at Big Inc. use a two-step process to manage the assets and risk in the pension portfolio. First, they use a VAR-based risk budgeting process to determine the asset allocation across four broad asset classes. Then, within each asset class, they set a maximum tracking error allowance from a benchmark index and determine an active risk budget to distribute among individual managers. Assume the returns are all normally distributed. From the first step in the process, the following information is available.

	Expected Return (%)	Volatility (%)	Asset Allocation (%)	Individual VAR (USD)	Marginal VAR
Small cap	0.20%	2.66%	35.0%	6,491	0.055
Large cap	0.15%	2.33%	40.0%	6,497	0.044
Commodities	0.10%	1.91%	16.7%	2,216	0.020
Emerging markets	0.15%	2.70%	8.3%	1,570	0.047
			Total VAR:	13,322	

Which of the following statements is/are *correct*?

I. Using VAR as the risk budgeting measure, the emerging markets class has the smallest risk budget.
II. If an additional dollar were added to the portfolio, the marginal impact on portfolio VAR would be greatest if it were invested in small caps.
III. As the maximum tracking error allowance is lowered, the individual managers have more freedom to achieve greater excess returns.
IV. Setting well-defined risk limits and closely monitoring risk levels guarantee that risk limits will not be exceeded.

a. I and II only
b. I, II, III, and IV
c. II and III
d. I only

29.4 IMPORTANT FORMULAS

Absolute risk: $\sigma(\Delta P) = \sigma(\Delta P/P) \times P = \sigma(R_P) \times P$

Relative risk: $\sigma(e)P = [\sigma(R_P - R_B)] \times P = \omega \times P$

Tracking error volatility (TEV): $\omega = \sigma(\Delta P/P - \Delta B/B)$

Sharpe ratio (SR): $SR = [\mu(R_P) - R_F]/\sigma(R_P)$

CHAPTER 30

Hedge Fund Risk Management

The first hedge fund was started by A. W. Jones in 1949. Unlike the typical equity mutual fund, the fund took long *and* short positions in equities. Over the subsequent decades, the hedge fund industry has undergone exponential growth. As of December 2009, hedge funds accounted for more than $1,600 billion in equity capital, called **assets under management** (AUM).

Hedge funds are organized as private partnerships and as a result differ in a number of essential ways from mutual funds. They provide more flexible investment opportunities and are less regulated. They have very few limitations on their investment strategies. In particular, they can take long and short positions in various markets and can use leverage. Due to this leverage, the assets they control are greater than their AUMs. Hedge funds have become an important force in financial markets, accounting for the bulk of trading in some markets.

Unlike mutual funds, which are open to any investor, hedge funds are accessible only to accredited investors, perhaps due to their perceived risks. To control their risk, most hedge funds have adopted risk controls using position-based, value at risk (VAR)-type techniques. Because some types of hedge fund strategies are very similar to those of proprietary trading desks of commercial banks, it was only natural for hedge funds to adopt similar risk management tools.

The purpose of this chapter is to provide an overview of risk management for the hedge fund industry. Section 30.1 gives an introduction to the hedge fund industry. Section 30.2 presents the mechanics of shorting and various measures of leverage. Section 30.3 then analyzes commonly used strategies for hedge funds and shows how to identify and measure their risk. The risk factors that are largely specific to hedge funds are presented in Section 30.4. Last, Section 30.5 shows how to deal with hedge fund risk.

30.1 THE HEDGE FUND INDUSTRY

The growth of the hedge fund industry is described in Figure 30.1. By now, there are close to 9,000 hedge fund managers[1] controlling close to $1,600 billion in

FRM Exam Part 2 topic.

[1] This number includes funds of funds, which add up to approximately 2,200.

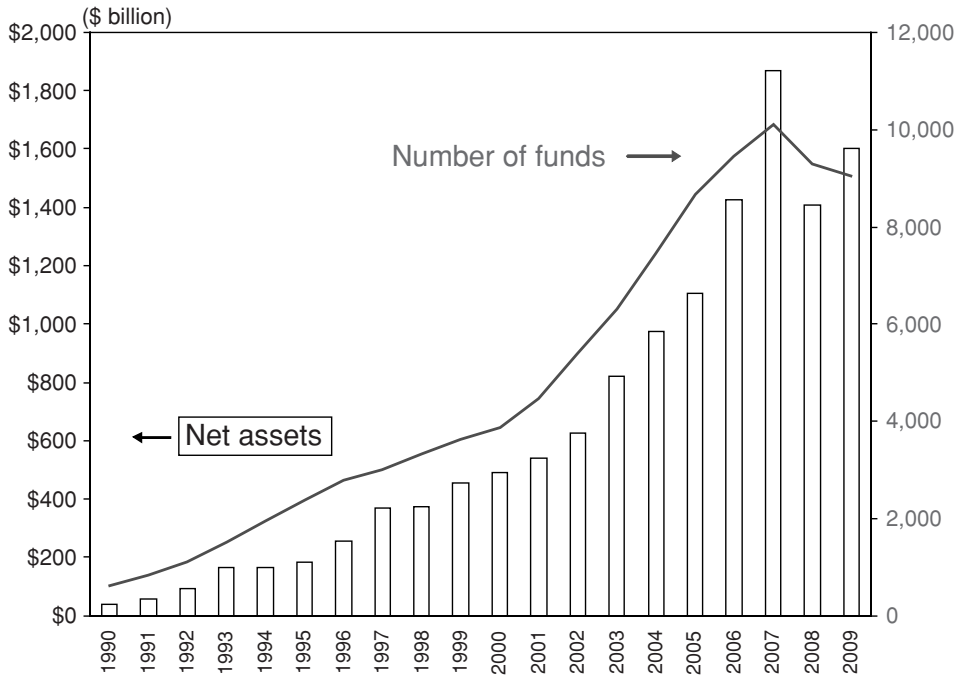

FIGURE 30.1 Growth of Hedge Fund Industry
Source: Hedge Fund Research. Data as of December of each year.

equity capital, also called net assets, up from $40 billion in 1990. This represents an annualized rate of growth of more than 20%. In comparison, U.S. mutual funds currently manage $11,121 billion, up from $1,065 billion in 1990. This represents an annualized rate of growth of 13%. Thus, hedge funds have grown much faster than mutual funds over the same period.

The growth of this industry is due to a number of factors. On the investor side, the performance of hedge funds has been attractive, especially compared to the poor record of stock markets during the 2000–2002 period. Hedge funds also claim to have low betas, which makes them useful as diversifiers.

On the manager side, hedge funds provide greater remuneration than traditional investment funds. Typical investment management fees for mutual funds range from a fixed 0.5% to 2% of AUM. In contrast, hedge funds commonly charge a fixed management fee of 1% to 2% of assets plus an incentive fee of 20% of profits.

Hedge funds also typically have fewer restrictions on their investment strategies and are less regulated, giving more leeway to portfolio managers. More flexible investment opportunities include the ability to short securities, to leverage the portfolio, to invest in derivatives, and generally to invest across a broader pool of assets. The lighter regulatory environment creates an ability to set performance fees, lockup periods, or other forms of managerial discretion.

The unprecedented turbulence of 2008, however, has hit the hedge fund industry hard. Many funds posted poor performance and suffered widespread investor redemptions, leading to many hedge fund closures. Even so, hedge funds in general suffered only half the loss of equities.

Example: Computing Fees

The most common fee structure consists of (1) a management fee that is a fixed proportion of assets under management, typically 2%, and (2) an incentive fee, which is typically 20% of the profits over a year when positive. Sometimes, the incentive fee is paid after the performance exceeds a **hurdle rate**, such as LIBOR.

As an example, assume that the net asset value (NAV) goes from 100 to 120 over the year before fees (gross) and that LIBOR is at 5%. Fees are at the usual 2 and 20. The management fee is deducted first from the ending asset value, which drops from 120 to 118. The total fee is then $100 \times 2\% + [(118 - 100) - 5\% \times 100] \times 20\%$. In this case, the gross return is 20%, the total fees to the manager are 4.6%, and the net return is 15.4%. Without a hurdle, the net return would be 14.4%.

30.2 LEVERAGE, LONG POSITIONS, AND SHORT POSITIONS

Hedge funds can achieve leverage and implement short sales through their **prime broker** (PB). PBs provide various back-office services to hedge funds, including trade reconciliation (clearing and settlement), custody services, risk management, as well as record keeping. In addition, they provide credit lines for financing leverage and short-selling capabilities.

To understand the mechanics of hedge funds, we need to describe how stock borrowing and margins work. In typical corporate balance sheet analysis, **balance sheet leverage** is defined as the ratio of balance sheet assets over equity. This simplistic measure, however, assumes that all the risk is coming from the assets, or that the future value of liabilities is known. Such a definition is not adequate for hedge funds, or most financial institutions, for that matter. In these cases, both assets and liabilities, long and short positions, are risky.

In what follows, we illustrate the use of long and short positions in stocks. This analysis, however, can be extended to any asset that can be shorted, subject to its own specific margin requirements.

30.2.1 Long Position

Let us start with the simplest case, which is a long position in a risky asset. Consider an investor with \$100 (say millions) invested in one stock. This can be achieved with \$100 of investor equity. Or the investor can borrow. Suppose the broker requires a 50% margin deposit, which is the minimum requirement under **Regulation T** in the United States. The investor needs to invest only \$50 and the remainder is provided by the broker, who gives a \$50 loan. The balance sheet of the position is as follows, with the risky entry in bold. Defining leverage as the ratio of assets over equity, the leverage of this position is 2 to 1.

Assets	Liabilities
\$100 **Long stock**	\$50 Broker loan
	\$50 Equity

The risk is that of a *decrease* in the value of the stock. For instance, a loss of \$1, which is 1% of the value of the stock, translates into a \$1 loss in the value of equity, which is a 2% loss in relative terms. Thus, movements in the asset value are magnified by the leverage factor L. If there is no leverage ($L = 1$), the worst loss occurs when the stock price goes to zero.

The rate of return on the equity is the summation of L times the rate of return on the long stock position R_S minus $(L - 1)$ times the cost of the loan, R_F:

$$R_E = LR_S - (L - 1)R_F = R_F + L(R_S - R_F) \tag{30.1}$$

Hence the volatility of equity will be L times that of the stock position. Similarly, the beta and idiosyncratic volatility are multiplied by the leverage:

$$\beta_E = L\beta_S \tag{30.2}$$

Leverage amplifies returns but also creates more risk.

Note that leverage can also be obtained by using derivatives, instead of cash instruments. This includes single stock futures, contracts for differences, or equity swaps. If a stock futures position can be entered with a margin of only 10%, the economically equivalent liabilities would consist of a loan of \$90 plus equity of \$10. The dollar exposure is still the same, at \$100, but the embedded leverage is now much higher than before, at 10 to 1.

30.2.2 Short Position

Consider next a situation where the investor wants to short the stock instead. Under a stock loan agreement, the owner of a stock lends the stock to our investor in exchange for cash and a future demand to get the stock back. In the meantime, the investor must pass along any cash flow on the stock, such as dividends, to the original owner.[2] When the operation is reversed, the stock lender returns the cash plus the short-term interest rate minus a **stock loan fee**. This is typically 20 basis points (bp) for most stocks but can reach 400 bp for stocks that are hard to borrow (said to be "on special"). In the meantime, the stock lender will have invested the cash, thus earning a net fee of 20bp. From the viewpoint of the stock lender, this is an easy way to increase the return on the stock by a modest amount.

The stock borrower will now sell the stock in anticipation of a fall in the price. The sale, however, will go through a broker, who will not allow the seller to have full access to the sales proceeds. In the United States, under Regulation T, the broker keeps 50% of the sales proceeds. This margin, which can be posted as any security owned clear by the investor, imposes a limit on the investor's leverage.

So, the investor receives \$100 worth of stocks, sells it, and keeps at least \$50 as margin with the broker. The hope is for a fall in the stock price, so that the stock can be repurchased later at a lower price.

All of the cash flows are arranged at the same time. The investor needs to send \$100 to the stock lender, half of which will come from the remaining proceeds and

[2] Traditional stock loans are made on a day-to-day basis. The lender can demand the return of the stock at any time, with a three-day period for delivery.

the other half from the equity invested, or the investor's own funds. The balance sheet for the short position is as follows, with the risky entry in bold. Here, leverage can be defined as the ratio of the absolute value of the short position to the equity, which is 2 to 1. As in the previous long-only case, we have a position of \$50 in equity leveraged into a position of \$100 in stocks. Regulation T imposes a maximum leverage ratio of 2, which is the inverse of the 50% of the short-sales proceeds kept by the broker.

Assets	Liabilities
\$100 Cash lent to stock owner	\$100 **Short stock**
\$50 Margin at the broker	\$50 Equity

Here, the risk is that of an *increase* in the value of the stock. If the stock price goes up by \$1, or 1%, the equity loses \$1, which is 2% in relative terms. This ratio equals the leverage of 2. The beta of the equity is now negatively related to that of the stock:

$$\beta_E = -L\beta_S \tag{30.3}$$

Short positions are intrinsically more risky than long positions, however. This is because the distribution of prices is asymmetrical. The price has a lower bound of zero but has unlimited upper values, albeit with decreasing probabilities. With a long position, the most that could be lost is \$100 million. With a short position, the price could go from \$100 to \$200 million or even higher, in which case the dollar loss would exceed \$100 million.

30.2.3 Long and Short Positions

Consider now a typical hedge fund, which has both long and short positions. Say the initial capital is \$100. This is the equity, or **net asset value** (NAV). The fund could buy \$100 worth of stocks and short \$100 worth of stocks as before. Part of the long stock position can be used to satisfy the broker's minimum margin requirement of \$50 for shorting the stock. The balance sheet for the long and short positions is as follows, with the risky entries in bold.

Assets	Liabilities
\$100 **Long stock**	\$100 **Short stock**
\$100 Cash lent to stock owner	\$100 Equity

Let us now turn to traditional risk measures. Define V_L, V_S, and V_E as the (absolute) dollar values of the long stock positions, short stock positions, and equity, respectively. V_A is the value of total assets. If β_L and β_S are the betas of the long and short stock positions, the total dollar beta is

$$(\beta_L\ V_L - \beta_S V_S) = \beta_E V_E \tag{30.4}$$

which defines the net beta of equity, or β_E. This net measure of systematic risk, however, ignores idiosyncratic risk.

Traditional **leverage** is commonly used as a risk measure

$$\text{Leverage} = \frac{V_A}{V_E} = \frac{\text{Long Stock Positions plus Cash}}{\text{Equity}} \tag{30.5}$$

In our example, this is ($100 + $100)/($100) = 2. Usually, cash is ignored, and **long leverage** is 1. This, however, ignores the hedging effect of short stock positions, so it is inadequate.

Using gross amounts, **gross leverage** is

$$\begin{aligned}\text{Gross Leverage} &= \frac{V_L + V_S}{V_E} \\ &= \frac{\text{Long Positions plus Absolute Value of Short Positions}}{\text{Equity}}\end{aligned} \tag{30.6}$$

In our example, this is ($100 + $100)/($100) = 2.

Gross leverage is often used as a rough measure of hedge fund risk. This measure, however, fails to capture the systematic risk of the equity position adequately. If the long and short positions have the same value and market beta, the net beta is zero, so there is no directional market risk. In the limit (even though there would be no reason to do so), if the long and short positions are invested in the same stock, there is no risk. Yet, gross leverage is high.

Another definition often used is **net leverage**, which is

$$\begin{aligned}\text{Net Leverage} &= \frac{V_L - V_S}{V_E} \\ &= \frac{\text{Long Positions minus Absolute Value of Short Positions}}{\text{Equity}}\end{aligned} \tag{30.7}$$

In our example, this is ($100 − $100)/($100) = 0.

Net leverage is also inadequate as a risk measure. Although it roughly accounts for systematic risk, it fails to take into account potential divergences in the value of the long and short positions. It is appropriate only under restrictive assumptions. For example, if the betas of the long and short positions are the same, then the equity beta is

$$\beta_E = \frac{\beta_L(V_L - V_S)}{V_E} = \beta_L \times \text{Net Leverage} \tag{30.8}$$

so this net leverage term measures the multiplier applied to the beta of the long position. This totally ignores idiosyncratic risk, however, which is precisely the type of risk that the hedge fund manager should take views on. In conclusion, these leverage measures should be viewed as only rough indicators of risk. They are robust and easy to compute, however.

This is why the industry has moved to more comprehensive position-based risk measures. VAR, for example, accounts for the size of positions and volatilities, as

well as correlations between assets and liabilities. As such, it is a superior measure of the risk of loss.

EXAMPLE 30.1: FRM EXAM 2006—QUESTION 41

A hedge fund is long $315 million in certain stocks and short $225 million in other stocks. The hedge fund's equity is $185 million. The fund's overall beta is 0.75. Calculate the gross and net leverage.

a. 2.91 and 0.48
b. 2.18 and 0.36
c. 2.91 and 0.36
d. 2.18 and 0.48

EXAMPLE 30.2: HEDGING AND RETURNS

Continuing with the previous question, assume the stock market went up by 20% last year. Ignore the risk-free rate and idiosyncratic risk, and assume the average beta of both long and short positions is 1. Over the same period, the return on the fund should be about

a. 20%
b. 15%
c. 10%
d. 5%

EXAMPLE 30.3: FRM EXAM 2004—QUESTION 2

A relative value hedge fund manager holds a long position in asset A and a short position in asset B of roughly equal principal amounts. Asset A currently has a correlation with asset B of 0.97. The risk manager decides to overwrite this correlation assumption in the variance-covariance-based VAR model to a level of 0.30. What effect will this change have on the resulting VAR measure?

a. It increases VAR.
b. It decreases VAR.
c. It has no effect on VAR, but changes profit or loss of strategy.
d. There is not enough information to answer.

30.3 HEDGE FUNDS: MARKET RISKS

30.3.1 Types of Market Risks

Hedge funds are a much more heterogeneous group of investment managers than others. They follow a great variety of strategies, which can be classified into different styles. More generally, they can be categorized into taking directional or nondirectional risks.

- **Directional risks** involve exposures to the direction of movements in major financial market variables. These directional exposures are measured by first-order or linear approximations such as
  - **Beta** for exposure to general stock market movements
  - **Duration** for exposure to the level of interest rates
  - **Spread duration** for exposure to movements in credit spreads
  - **Delta** for exposure of options to the price of the underlying asset
- **Nondirectional risks** involve other remaining exposures, such as nonlinear exposures, exposures to hedged positions, and exposures to volatilities. These nondirectional exposures are measured by exposures to differences in price movements, or quadratic exposures such as
  - **Basis risk**, which involves differences in prices of related assets
  - **Convexity risk**, which involves quadratic effects for interest rates
  - **Gamma risk**, which involves quadratic effects with options
  - **Volatility risk**, which involves movements in volatility

Directional trades can take long or short positions on the major risk factors, such as equities, currencies, fixed-income instruments, and commodities. As a result, directional positions have greater volatilities than nondirectional ones. For funds that take directional risks, total portfolio risk is controlled through diversification across sources of risks, across trading strategies, and with risk limits.

Many categories of hedge funds are hedged against directional risks. As a result, they are exposed to nondirectional risks. Such strategies need to take long *and* short positions in directional trades. The example we gave in the previous section was long $100 in a stock offset by a short position worth $100 in another stock. Such a strategy has little directional risk to the stock market, but is exposed to changes in the relative value of the two stocks. Limiting risk also limits rewards, however. As a result, nondirectional strategies are often highly leveraged in order to multiply gains from taking nondirectional bets.

30.3.2 Hedge Fund Styles

Hedge funds can be classified into various styles, reflecting the types of trading and markets they are exposed to. Table 30.1 lists various hedge fund styles. To some extent, this classification is arbitrary. Definitions of categories vary within the industry. Different hedge fund index providers, for example, use different classifications, even though the underlying pool of hedge funds is similar.

TABLE 30.1 Hedge Fund Styles

Style	AUM ($b)	Number of Funds	Risk (% pa)	Description
Directional Strategies				
Long/short equity	424	975	11%	Combination of long and short equity positions with net long bias
Emerging markets	115	205	12%	Equity and bond positions in emerging countries, with net long bias
Global macro	122	148	11%	Long and/or short positions across all asset classes
Nondirectional Strategies				
Relative value:				
Equity market neutral	71	183	6%	Combination of long and short equity positions with net beta close to zero
Fixed-income arbitrage	59	138	6%	Offsetting long and short positions in fixed-income securities
Convertible arbitrage	39	79	5%	Long positions in convertible bonds hedged for stock risk and interest risk
Event driven: Merger arbitrage, distressed securities, credit hedging	318	289	6%	Positions driven by corporate events such as mergers, reorganizations, and bankruptcy proceedings
Fund Structure				
Managed futures	57	235	17%	Positions in futures and option contracts (includes CTAs)
Multistrategy	181	262	9%	Combinations of hedge fund strategies in the same fund
Funds of funds		872	6%	Diversified portfolios of hedge funds

Source: TASS database, sample of live funds reporting in U.S. dollars as of December 2007. Risk is cross-sectional average of annualized volatility over the past four years.

Classifications can also lose meaning if hedge fund managers change strategies over time.

The table also reports the number of existing funds in each group, as well as their typical risk, measured as the annual standard deviation averaged across all funds.[3] Styles are generally listed in order of decreasing risk.

Table 30.2 presents the performance of typical hedge fund indices, measured over the period 1994 to 2009. Credit Suisse First Boston (CSFB) builds each sector index as a value-weighted average of eligible funds. The table shows the compound growth, volatility, beta to the S&P 500 stock index, return in excess of cash, and the alpha from a regression on equities.

The table shows that the overall hedge fund index returned 9.3% over this period, which is above the 7.6% return of the S&P 500 index, with much lower volatility. The index, however, has slightly positive beta of 0.27, so part of its performance is due to the equity premium. The last column shows an alpha of 4.2%, which is significant.

[3] Note that the risk measures are for live funds only. Hence, the data are subject to survivorship bias. The risk of existing funds is less than that of dead funds.

TABLE 30.2 Hedge Fund Performance: CSFB Indices, 1994 to 2009

	Growth	Volatility	Beta	Excess Return	Alpha
Overall index	9.3%	7.8%	0.27	5.2%	4.2%
Sectors:					
Long/short equity	10.3%	10.0%	0.41	6.2%	4.8%
Short biased	−2.5%	16.9%	−0.80	−6.6%	−3.8%
Emerging markets	8.0%	15.6%	0.53	3.9%	2.1%
Global macro	12.4%	10.3%	0.16	8.3%	7.7%
Equity market neutral	5.5%	10.8%	0.18	1.3%	0.7%
Fixed-income arbitrage	4.8%	6.1%	0.14	0.7%	0.2%
Convertible arbitrage	7.7%	7.2%	0.16	3.6%	3.0%
ED—merger arbitrage	11.2%	6.7%	0.26	7.1%	6.2%
ED—distressed securities	9.8%	6.4%	0.22	5.7%	4.9%
ED—credit hedging	7.4%	4.2%	0.13	3.2%	2.8%
Managed futures	6.3%	11.8%	−0.11	2.2%	2.5%
Multistrategy	8.4%	5.5%	0.11	4.2%	3.9%
Benchmarks:					
Cash	4.1%	0.0%	0.00	0.0%	0.0%
S&P 500 index	7.6%	15.5%	1.00	3.5%	0.0%
Treasury index	5.9%	4.8%	−0.03	1.8%	
High-yield index	7.0%	9.5%	0.37	2.9%	

Note: Excess returns are measured relative to one-month London Interbank Bid Rate (LIBID). Alpha is measured from a market model regression on the S&P 500 index. ED—event driven.

Also note that the volatility in this table is not directly comparable to that in Table 30.1, because this is the volatility of a portfolio, instead of the average fund volatility. In contrast, the beta of a portfolio is a weighted average of the fund betas, so the portfolio beta gives a good indication of the typical beta of individual funds.[4]

Long/Short Equity The first category consists of directional strategies. These include **long/short equity funds**, which, as Table 30.1 shows, is the most prevalent strategy. These funds are not market neutral. Most have a long bias (e.g., 100% of NAV in long positions, and 50% in short positions). Table 30.2 indeed shows a beta of 0.41.

A related category consists of **short biased funds**, which are net short. Table 30.2 shows a negative beta, close to −1. Another category is **emerging markets funds**, which consists of equity and bond positions in emerging countries, such as Brazil, Russia, India, and China.

These funds are exposed to the general market risk factor, in addition to sector and idiosyncratic risks. Because of leverage, volatility is high, at 11% on average across all such funds. This is on the order of the volatility of an unleveraged position in the S&P 500.

[4] In addition, the numbers are not directly comparable across the two tables because they are measured over different periods.

Global Macro Next are **global macro funds**, which take directional, leveraged bets on global asset classes, equities, fixed-income securities, currencies, and commodities. Because they span so many markets, these funds do not have a homogeneous risk profile. An example is George Soros's fund that shorted the British pound against the German mark just before the pound's devaluation, leading to a reported gain of $1 billion for the hedge fund. This group is close to **global tactical asset allocation** (GTAA), which is a traditional investment manager category. GTAA managers take positions across national stock markets, fixed-income markets, and currencies to take advantage of short-term views, often through derivatives.

These funds are exposed to a number of general market risk factors, in addition to sector and idiosyncratic risks. The average volatility is 11%. This is less than the previous category because these funds also invest in other markets, which are less volatile than equities.

We now turn to nondirectional strategies. The next three categories are sometimes called **relative value funds**, because they rely on comparisons of securities with similar characteristics, buying the cheap ones while selling the expensive ones in the hope of future convergence.

Equity Market Neutral The first group is **equity market neutral funds**, which attempt to maintain zero beta through balanced long and short positions in equity markets. These funds may or may not be neutral across other risk factors, including industries, styles, and countries.

So, these funds are exposed to these other risk factors (industries, styles, countries) in addition to idiosyncratic, stock-specific risks. Balance sheet leverage is typically three times on each side; that is, both longs and shorts add up to 300% of equity. The average volatility is 6%, which is much less than that of equity indices, due to the hedging effect of the short positions.

Fixed-Income Arbitrage The next group is **fixed-income arbitrage funds**. This is a generic term for a number of strategies that involve fixed-income securities and derivatives. The hedge fund manager assesses the relative value of various fixed-income instruments.

For instance, on-the-run bonds are the most recently issued bonds within a maturity range and hence the most liquid; otherwise, the bonds are called off-the-run. If the on-the-run bond is very expensive relative to the off-the-run bond, the fund would buy the undervalued security and sell the expensive one. This position has a net duration close to zero but is exposed to the spread between the two securities. Other examples include taking positions in swap spreads, or in asset-backed securities when their option-adjusted spread is high. This group includes mortgage arbitrage.

These funds avoid directional exposures to interest rates but are exposed to other nondirectional risks, such as spread risk. Due to the small expected profit of each trade, fixed-income arbitrage funds are highly leveraged, with leverage ratios ranging from 10 to 25.

Example: LTCM's Bet

Long-Term Capital Management (LTCM) started as a fixed-income arbitrage fund, taking positions in relative value trades, such as duration-matched positions in long swaps, short Treasuries. It started the year 1998 with $4.7 billion in equity capital.

On August 21, 1998, the 10-year Treasury yield dropped from 5.38% to 5.32%. The swap rate, in contrast, increased from 6.01% to 6.05%. This divergence was highly unusual. Assuming a notional position of $50 billion and modified duration of eight years, this leads to a value change of $-8 \times (5.32 - 5.38)/100 \times \$50{,}000 = +\$240$ million on a long Treasury position and $-8 \times (6.05 - 6.01)/100 \times \$50{,}000 = -\$160$ million on a long swap position. As the spread position is long the swap and short Treasuries, this leads to a total loss of $400 million, close to 10% of capital.

LTCM also took positions in option markets, selling options when they were considered expensive and dynamically hedging to maintain a net delta of zero. Implied volatilities went up sharply on August 21, leading to further losses on the option positions. On that day, LTCM's reported loss was $550 million.

The average volatility of this group is 6%. The distribution of payoffs is typically asymmetric, however. Swap spreads, for example, cannot narrow below zero but can increase to very large values, and have done so. This asymmetry in the distribution of spreads is reflected in that of profits. Such hedge funds have negatively skewed distribution. When they lose money, they can lose large amounts.

Convertible Arbitrage The last group in the relative value category is **convertible arbitrage funds**. The hedge fund manager assesses the relative value of convertible bonds using proprietary option pricing models. If the convertible bond is cheap, the hedge fund buys the bond while hedging the major risks.

Because a convertible bond involves a long call option position, it has positive delta with respect to the underlying stock. Therefore, the manager should short the stock to bring the net delta of the position close to zero. Typically, interest rate risk is hedged by shorting Treasury bonds, or T-bond futures. Sometimes, credit spread risk is hedged by buying credit default swaps.

These funds avoid directional exposures to interest rates but are exposed to other nondirectional risks, such as spread risk. Being typically long convertible bonds, the long option position creates positive gamma and vega (long implied volatility). The bond position creates positive convexity, unless the bond is callable. This strategy is also exposed to corporate event risk, such as default (if not hedged) and takeover. Leverage is moderate. Typically, the long convertible bond position is no more than three times equity. The average volatility of this group is 5%, which is fairly low, in part because of illiquidity.

Event Driven The next group includes **event-driven funds**, which attempt to capitalize on the occurrence of specific corporate events. This group includes **merger arbitrage funds** and **distressed securities funds**.

Let us focus first on merger arbitrage funds, also known as **risk arbitrage funds**. **Mergers and acquisitions** are transactions that combine two firms into one new firm.[5] The parties can be classified as the **acquiring firm**, or bidder, which initiates the offer, and the **target firm**, or acquired firm, which receives the offer. The bidder offers to buy the target at a **takeover premium**, which is the difference between the offer price and the target's stock price before the bid. This premium is typically high, averaging 50% of the initial share price.

Upon the announcement of the merger, the price of the target firm reacts strongly, increasing by, say, 40%. This still falls short of the takeover price, due to the uncertainty as to whether the transaction will occur. The completion rate is 83% on average, so there is always a possibility the transaction could fail. When this happens, the target firm typically suffers a large price drop. As a result, it is important to diversify by spreading the portfolio over many deals.

Offers can take the form of cash or stock of the bidding company. For a cash deal, the risk arbitrage position simply consists of buying the target's stock, and hoping the price will eventually move to the takeover price. For a stock deal, the bidder offers to exchange each target share for Δ shares of the bidder. The risk arbitrage position then consists of a long position in the target offset by a short position of Δ in the bidder's stock. These positions generate an average annualized excess return of 10%.[6]

The volatility of this group is relatively low. Because the stochastic process for the target's stock price changes after the announcement, traditional position-based risk measures are not appropriate measures of risk.[7]

Example: Exxon–Mobil Merger

On December 1, 1998, Exxon confirmed that it had agreed to buy Mobil, another major oil company, in a transaction valued at $85 billion, which was the biggest acquisition ever. The deal created the world's largest traded oil company, with a market capitalization of $250 billion. Under the terms of the agreement, each shareholder of Mobil would receive $\Delta = 1.32015$ shares of Exxon in exchange.

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[5] These are sometimes called takeovers. Takeovers can take the form of mergers or tender offers. Mergers are negotiated directly with the target managers, approved by the board of directors, and then approved by shareholder vote. Tender offers are offers to buy shares made directly to target shareholders.

[6] This is a risk-adjusted excess return. These profits, however, seem to be related to limits to arbitrage, as they are lower for firms that are large and have low idiosyncratic risk. See M. Baker and S. Savasoglu, "Limited Arbitrage in Mergers and Acquisitions," *Journal of Financial Economics* 64 (2002): 91–115.

[7] See P. Jorion, "Risk Management for Event-Driven Funds," *Financial Analysts Journal* 64 (2008): 61–73.

Before the announcement, the initial prices of Mobil and Exxon were \$78.4 and \$72.7, respectively, which implies a modest premium of $(1.32016 \times \$72.7)/\$78.4 - 1 = 22\%$. Over the three days around the announcement, Mobil's stock price went up by +6.9% to \$84.2 and Exxon's price went down by −1.5% to \$71.6. This stock price reaction is typical of acquisition announcements.

The exchange was consummated on November 30, 1999, after regulatory and shareholder approval. On that day, the respective stock prices for Mobil and Exxon were \$104.4 and \$79.3. Multiplying the latter by 1.32015, we get \$104.7, which is close to the final stock price for Mobil. So, the two prices converged to the same converted value. The profit from the risk arbitrage trade was $(\$104.4 - \$84.2) - 1.32016(\$79.3 - \$71.6) = \$10.0$ per share.

Event-driven funds also include **distressed securities funds**, which take positions in securities, debt or equity, of firms in financial difficulty. In such situations, the hedge fund manager needs to assess the effect of restructuring or the bankruptcy process on the market price of the securities. This requires an evaluation of the financial situation of the firm, as well as a good understanding of legal issues involved. If, for instance, the debt of a bankrupt company trades at 40 cents on the dollar, the hedge fund would benefit if the total payment after reorganization is 50 cents. Such funds are also actively involved in the bankruptcy processes and the reorganization plans.

These funds are exposed to event risks, that is, that the takeover or reorganization fails. They may also be exposed to equity market risk and interest rate risk if these exposures are not hedged. Because distressed securities do not trade actively, there is also liquidity risk.

Leverage for event-driven funds is low to moderate, no more than two times. The average volatility for event-driven funds is 6%, which is fairly low. This, however, hides the fact that the distribution of payoffs is asymmetric. Typically, the upside is more limited than the downside, should the takeover or reorganization fail. So, these funds are short volatility, or exposed to rare events. Because of the unusual nature of the event, measures of risk based on historical returns can be inaccurate for forecasting risk.

Managed Futures Funds The next category of hedge funds differs from others on the basis of the fund structure. **Managed futures funds** consist of managers who use commodity and financial futures and options traded on organized exchanges. Trading strategies often involve **technical trading**, where positions depend on patterns in price histories. Leverage is high, leading to high volatility.

These funds have directional exposures to all the markets that have listed futures contracts. Their risk factors overlap with global macro funds. GTAA strategies, for instance, often involve stock index and currency futures. The average volatility of this group is 17%, which is fairly high.

Multistrategy Funds Next, **multistrategy funds** are hedge funds that cover combinations of previously described fund strategies. One advantage of such funds is

that they can reallocate capital quickly from one strategy to another. They also provide automatic diversification across strategies. The average volatility of this group is 9%.

However, multistrategy funds tend to be more concentrated in one type of strategy, and do not provide as much diversification as funds of funds, described next. Amaranth, for example, initially started as a multistrategy fund focused on convertible bond arbitrage, then morphed into a natural gas trading operation, and eventually blew up. Because all strategies are run within the same fund, a large loss in one strategy may affect the capital of other strategies. In other words, strategies are not firewalled, unlike in the fund of funds structure.

Funds of Funds Finally, **funds of funds**, also called **multimanager funds**, are portfolios of hedge funds. These add value by careful selection of styles and investment managers. They also perform essential functions, such as the due diligence process when evaluating new managers and their continuous monitoring. Funds of funds can take views on strategies, increasing allocation to strategies that are expected to perform better.

Funds of funds charge additional management fees on top of those levied by the underlying funds, typically around 1%. However, because of their size, funds of funds can negotiate lower fees from the hedge fund managers.

Relative to multistrategy funds, funds of funds have higher fees. This cost difference, however, is offset by the fact that a fund of funds has access to the best managers, who generally want to run their own fund, thus creating better performance.

Also, funds of funds have lower risk of losses due to blowups than multistrategy funds, where the entire investment can be lost, as in the case of Amaranth. There are two reasons for this. First, funds of funds are generally better diversified across strategies than are multistrategy funds. Second, the hedge funds in a fund of funds pool are legally separate from each other (i.e., are firewalled). As a result, a blowup in one hedge fund will not contaminate the rest of the portfolio, unlike what can happen in the case of a multistrategy fund.

Funds of funds provide convenient access to a diversified portfolio of hedge funds. Because hedge funds have minimum investment amounts, such diversification is difficult to achieve for small mandates allocated to hedge funds. For example, a $100 million allocation to hedge funds can be realistically invested in at most 10 hedge funds. A typical fund of funds, in contrast, will invest in 50 funds. Funds of funds provide economies of scale in the due diligence and risk monitoring processes. Funds of funds can also negotiate greater capacity and better liquidity than other investors.

Table 30.1 shows that the average volatility of this group is 6%. This low number reflects effective diversification across managers and styles.

This list makes it clear that hedge funds are a very heterogeneous group. They are exposed to a wide variety of risk factors, follow different trading rules, and have varying levels of leverage and risk. The common element, however, is the need to manage risk.

EXAMPLE 30.4: FRM EXAM 2009—QUESTION 8-7

A fund of hedge funds combines a mix of strategy sectors, managers, and styles, and therefore fund of funds risk managers need to understand the common attributes of hedge fund strategies. Which of the following statements is *incorrect*?

a. Equity market neutral funds aim to generate returns that have low correlation to the overall equity market and to insulate their portfolios from broad market risk factors.
b. Convertible arbitrage funds typically purchase securities that are convertible into the issuer's stock and simultaneously short the underlying stock. These funds earn returns in part from gamma trading on the stock's volatility.
c. Merger arbitrage funds buy the stock of an acquisition target company and simultaneously short the bidding company's stock. These funds have large exposure to deal risk.
d. Equity short-selling funds sell stocks not currently owned by the seller in order to take a directional bet that the stock price will decline. These funds tend to be uncorrelated with traditional long-only equity portfolios.

EXAMPLE 30.5: RISKS IN FIXED-INCOME ARBITRAGE

Identify the risks in a fixed-income arbitrage strategy that takes long positions in interest rate swaps hedged with short positions in Treasuries.

a. The strategy could lose from decreases in the swap-Treasury spread.
b. The strategy could lose from increases in the Treasury rate, all else fixed.
c. The payoff in the strategy has negative skewness.
d. The payoff in the strategy has positive skewness.

EXAMPLE 30.6: RISKS IN CONVERTIBLE ARBITRAGE

Identify the risk in a convertible arbitrage strategy that takes long positions in convertible bonds hedged with short positions in Treasuries and the underlying stock.

a. Short implied volatility
b. Long duration
c. Long stock delta
d. Positive gamma

EXAMPLE 30.7: RISKS IN MERGER ARBITRAGE—I

A major acquisition has just been announced, targeting company B. The bid from company A is an exchange offer with a ratio of 2. Just after the announcement, the prices of A and B are $50 and $90, respectively. A hedge fund takes a long position in company B hedged with A's stock. After the acquisition goes through, the prices move to $60 and $120. For each share of B, the gain is

a. $30
b. $20
c. $10
d. $0 since the acquisition is successful

EXAMPLE 30.8: RISKS IN MERGER ARBITRAGE—II

Suppose the payoff from a merger arbitrage operation is $5 million if successful, −$20 million if not. The probability of success is 83%. The expected payoff on on the operation is

a. $5 million
b. $0.75 million
c. $0 since markets are efficient
d. Symmetrically distributed

EXAMPLE 30.9: FRM EXAM 2005—QUESTION 47

The Big Bucks hedge fund has the following description of its activities. It uses simultaneous long and short positions in equity with a net beta close to zero. Which of the following statements about Big Bucks is/are *correct*?

I. It uses a directional strategy.
II. It is a relative value hedge fund.
III. This fund is exposed to idiosyncratic risks.

a. I and II
b. II and III
c. I and III
d. II only

30.4 HEDGE FUNDS: SPECIFIC RISKS

30.4.1 Agency Risk

Hedge fund managers act as agents for investors. This can cause misalignment of incentives, however. Incentive fees make a payment that is a fraction of the profits, if positive. As a result, the hedge fund manager is long an option. Because the value of an option increases with the volatility, the fund manager may have an incentive to increase the risk of the fund.

Another potential problem is that of **style drift**, which occurs when managers change their investment patterns or stray into new markets.

This type of behavior can be minimized in a number of ways. Most importantly, hedge fund managers should invest a large fraction of their personal wealth in the fund they manage. This lessens the incentive to take on too much risk.

Some risk monitoring occurs at the level of the prime broker (PB). Because the PB is primarily concerned about the risk of loss from lending to the hedge fund, however, its interests do not align with those of fund investors. For example, a lender may use margin calls to force liquidation of the fund assets at distressed prices. As long as there is excess collateral, the lender would be protected, but at the expense of investors.

The incentive to take risk is also lessened with **high-water marks**, also known as loss carryforward provisions.[8] The manager receives performance fees only to the extent that the current net asset value (NAV) exceeds the highest NAV previously achieved. Suppose, for instance, that the NAV changes from $100 to $130 to $120 to $140 in four consecutive years. The $130 NAV year, the performance fee would apply to $30. The next year, there is no performance fee because the fund lost money. The final year, the performance fee applies only to the portion of $140 in excess of $130, which is the highest previous NAV. This mechanism, however, may not provide complete protection if the watermark is too high. In this case, the fund manager may choose to close the fund and to start a new one (if investors can be found).

30.4.2 Liquidity and Leverage Risk

Hedge funds take leveraged positions to increase returns, especially with nondirectional trades such as fixed-income arbitrage, where the expected return on individual trades is generally low.

Perversely, this creates other types of risks, including **liquidity risk**. This strategy indeed failed for Long-Term Capital Management (LTCM), a highly leveraged hedge fund that purported to avoid directional risks. LTCM had a leverage ratio of 25 to 1. It had grown to $125 billion in assets, four times the asset size of the next largest hedge fund. Once the fund started to accumulate losses, it became

[8] Sometimes, a **claw-back** provision is included, which requires the fund manager to pay back performance fees when the value of the fund drops.

difficult to cut positions given its size. LTCM also had to meet margin calls from brokers. The fund ended up losing $4.4 billion, or 92% of its equity.

Table 30.3 links sources of liquidity risk to a hedge fund balance sheet. Liquidity risk arises on the asset side and is a function of the size of the positions as well as of the price impact of a trade. On the liabilities side, funding risk arises when the hedge fund cannot roll over funding from its broker, or when losses in marked-to-market positions or increases in haircuts lead to cash outflows. This is often a major source of risk for hedge funds, as the failure to meet margin calls can lead the lender to seize the collateral, forcing liquidation of the fund. Finally, funding risk also arises when the fund faces investor redemptions.

The price impact function is instrument-specific. For example, major currencies, large stocks, Treasury bills, and Treasury bonds are very liquid, meaning that large amounts can be transacted without too much effect on the price. Other markets are by nature less liquid. For instance, minor currencies, small stocks, and most corporate debt instruments are generally illiquid.

LTCM dealt with mostly liquid instruments but was exposed to liquidity risk due to the sheer size of its positions. This is why hedge funds often say they have a **maximum capacity**. Beyond that optimal size, trading becomes difficult due to market impact.

Another type of risk that is exacerbated by leverage is **model risk**. This occurs when the investment strategy relies on valuation or risk models that are flawed. Due to leverage, small errors in the model can create big errors in the risk measure. Indeed, LTCM's risk measurement system was deficient, leading to a fatal underestimation of the amount of capital required to support its positions.

Some categories of hedge funds have intrinsic liquidity risk because the instruments are thinly traded, implying a large price impact for most trades. This is the case with convertible bonds and especially so with distressed securities. Because these funds invest in thinly traded securities, liquidity risk arises even for small funds.

Typically, funds with greater liquidity risk impose a longer **lockup period** and **redemption notice period**. The former refers to the minimum time period during which investor money is to be held in the fund. The latter refers to the period required to notify the fund of an intended redemption. Lockup periods average three months, and can extend to five years. Advance-notice periods average 30 days. Funds also often have **gates**, which limit the amount of withdrawals to a fraction of the net assets. In the extreme, funds might be able to impose an outright **suspension** of redemptions.

TABLE 30.3 Sources of Liquidity Risk

Assets	**Liabilities**
Size of position	Funding
Price impact	Mark-to-market, haircuts
	Equity
	Investor redemptions

Instrument liquidity risk creates a major problem for the measurement of risk. Typically, funds report their **net asset value** at the end of each month. If transaction prices are not observed at the end of the month, the valuation may be using a price from a trade that occurred in the middle of the month. This price is called a **stale price** because it is old and does not reflect a market-clearing trade on the day of reporting. Unfortunately, this will distort the reported NAVs as well as the risk measures.

The first effect is that the reported monthly volatility will be less than the true volatility. This is because prices are based on trades during the month, which is similar to an averaging process. Averages are less volatile than end-of-period values.

The second effect is that monthly changes will display positive autocorrelation. A movement in one direction will be only partially captured using prices measured during the month. The following month, part of the same movement will show up in the return. This positive autocorrelation substantially increases the risk over longer horizons. Consider, for instance, the extrapolation of a one-month volatility to two months. The usual adjustment factor is $\sqrt{T} = \sqrt{2} = 1.41$. With autocorrelation of $\rho = 0.5$, this adjustment factor is instead $\sqrt{(1 + 1 + 2\rho)} = \sqrt{2(1 + 0.5)} = 1.73$. The true risk is understated by $(1.73 - 1.41)/1.73 = 18\%$. This effect increases with the length of the horizon. As a result, the annualized volatility presented in Table 30.1, which extrapolates monthly volatility using the square root of time, may understate the true annual risk. Long-term measures of risk must specifically account for the observed autocorrelation.

A third, related effect is that measures of systematic risk will be systematically biased downward. If the market goes up during a month, only a fraction of this increase will be reflected in the NAV, leading to beta measures that are too low. Corrections to the beta involve measuring the portfolio's beta with the contemporaneous market return plus the beta with respect to the one-month lagged return plus the beta with respect to the one-month future return. With thin trading, the sum of these three betas should be higher than the contemporaneous beta, and also closer to the true systematic risk.[9]

Leverage can create other problems, which can be classified as **crowded trade risk**. This arises when many leveraged investors are on the same side of a trade.[10] A loss in their portfolios may require them to post additional margin, which may be satisfied by several funds selling similar assets at the same time, which can create disruptions in markets. Apparently, this explains why many **quant funds**, which are generally equity market neutral (EMN) strategies driven by quantitative models, suffered heavy losses in August 2007. The story is that

[9] This correction is called the *Dimson beta*. See E. Dimson, "Risk Measurement When Shares Are Subject to Infrequent Trading," *Journal of Financial Economics* 7 (1979): 197–226.

[10] Of course, other investors must be on the other side of the trade. This classification supposes that the other side is not so leveraged; otherwise, trades could be crossed without much effect on prices. In practice, positions are confidential, and it is impossible to know who is on which side of a trade, except anecdotally.

a large multistrategy fund lost money on credit trades and then liquidated its equity positions, because these are more liquid than others. This caused large losses in EMN portfolios, on both the long and the short sides, which was highly unusual.

This is not just a problem with leverage, however. Any mechanistic trading rule that involves cutting positions after a loss is incurred may have similar effects if there is an imbalance between demand and supply. This includes, for instance, stop losses, which are equivalent to synthetically replicating long positions in options.

30.4.3 Leverage and Counterparty Risk

Leverage also creates another type of risk, which is **counterparty risk**. Hedge funds that use leverage give collateral to prime brokers. **Hypothecation** is the pledge of client-owned securities in a margin account to secure a loan. The broker then has the right to **rehypothecate** the securities to another party. If the broker goes bankrupt, however, the rehypothecated assets become part of the claims against the broker.

In the case of the Lehman failure, $22 billion out of the $40 billion held by Lehman's European prime brokerage had been rehypothecated. As a result, hedge funds trying to reclaim these assets found themselves in the line of general creditors with claims against Lehman.

30.4.4 Fraud Risk

A last issue, especially with complex or illiquid assets, is **improper valuation of assets**. This problem arises when assets do not have market-clearing prices at the end of the reporting period and when fund managers calculate the NAV themselves. As a result, some unscrupulous hedge fund managers have succumbed to the temptation to misreport the value of the fund's assets in order to hide their trading losses.[11] Others have even stolen investors' assets.

Indeed, a recent study has shown that valuation problems played a role in 35% of hedge fund failures, and that 57% of those valuation problems were caused by fraud or misrepresentation.[12] The growth of the hedge fund industry, along with well-publicized occurrences of fraud, explains the trend toward requiring funds to **register** with the Securities and Exchange Commission (SEC) in the United States.[13]

[11] A 2003 report by the SEC, however, notes that there is no evidence that hedge fund advisers engage *disproportionately* in fraudulent activities.

[12] See C. Kundro and S. Feffer, "Valuation Issues and Operational Risk in Hedge Funds" (Capco white paper, 2003).

[13] The SEC issued a new rule in December 2004 that required hedge funds to register as investment advisers. This rule applied to U.S.-based hedge funds, and to non-U.S. funds that have at least 14 U.S. investors. Funds with less than $25 million under management did not have to comply. In June 2006, however, this registration requirement was annulled by the U.S. Court of Appeals. Even so, Congress created a new law in 2010 that requires most hedge funds to register with the SEC.

Registration gives the SEC the authority to conduct examinations of hedge fund activities. The goal is to help to identify compliance problems at an early stage and to provide a deterrent to fraud. Registration also requires the hedge fund to designate a **chief compliance officer**. In practice, however, the majority of U.S.-based hedge funds have voluntarily registered as investment advisers. Registration is often required by investors as a precondition for investing.

The possibility of fraud can be lessened when a fund has an independent **administrator**. Administrators perform day-to-day administrative duties associated with running a fund, in particular financial and tax reporting. They calculate net asset values, maintain the statutory books and records, and provide shareholder services. In addition, an outside **auditor** provides important additional information. Auditors issue a written opinion on the fair presentation of the fund's financial statements, typically on an annual basis. To protect against theft, investors should insist on an external **custodian**, which is a financial institution such as a bank or trust company that holds the fund's assets. Usually a fund's prime broker will perform the role of custodian.

Example: Ponzi Scheme

The term **Ponzi scheme** is attributed to Charles Ponzi, who in 1919 established an inventive pyramid scheme using new investor funds to repay earlier investors. The investment was based on a relative-value trade, in which postal coupons were bought overseas for the equivalent of one U.S. cent and resold for six American one-cent stamps. After transaction costs were factored in, however, the trade was unprofitable. Nevertheless, thousands of people invested with him, lured by a promise of 50% return in 90 days. Ultimately, he lost $140 million of investor funds, in today's dollars, and was jailed for fraud.

The most famous case of a Ponzi scheme since then was perpetrated by **Bernard Madoff**, who was arrested in December 2008 after admitting to defrauding investors of perhaps $50 billion through his brokerage firm, Bernard Madoff Investment Securities (BMIS). BMIS was established in 1960 and by the end of 2007 was managing about $17 billion in hedge fund investments. Returns to initial investors were paid using new investments. The scheme collapsed when investors sought about $7 billion in redemptions during 2008, which could not be met. Ponzi schemes work only as long as new money flows in.

Investors had been attracted by the high and steady returns from Madoff's funds, which turned out to have been fabricated. Many leading funds of funds, however, had performed due diligence on Madoff and had spotted enough warning signs to stay clear of him. BMIS acted as custodian of investor assets, had no external administrator, and relied on an unknown three-person audit firm. In addition, some people who had analyzed the options-trading strategy had concluded that it was infeasible because it would have implied trading volumes far in excess of exchange-traded volumes. This illustrates the value of a thorough due diligence process.

30.4.5 Regulatory Risks

Finally, hedge funds are also subject to **regulatory risks**. This is the risk of loss due to regulatory changes. In September 2008, for example, many countries put in place outright bans on short-selling equities.

This ban created havoc with strategies that rely on short sales to hedge. For example, the convertible bond arbitrage sector suffered extreme losses during these months. Statistical arbitrage funds, which take long and short positions in stocks, had to withdraw from many markets.

There is broad consensus, however, that such bans are ineffective at stopping prices from falling.[14] Such bans also have far-reaching consequences. In the case of convertible bonds, for example, the market freeze prevented many institutions, including banks, that traditionally issue convertible bond debt from raising new funds. In addition, such bans cause investors to withdraw from markets, sapping liquidity, which actually increases volatility. Bans on short-selling removed hedge funds' main mechanism for risk management, which led to an acceleration of withdrawal of capital when the market needed it most.

EXAMPLE 30.10: LIQUIDITY RISKS

Asset liquidity risk is most pronounced for

a. A $10 million position in distressed securities
b. A $10 million position in Treasury bonds
c. A $100 million position in distressed securities
d. A $100 million position in Treasury bonds

EXAMPLE 30.11: FRM EXAM 2006—QUESTION 112

For a portfolio of illiquid assets, hedge fund managers often have considerable discretion in portfolio valuation at the end of each month and may have incentives to smooth returns by marking values below actual, in high-return months and above actual, in low-return months. Which of the following is *not* a consequence of return smoothing over time?

a. Higher Sharpe ratio
b. Lower volatility
c. Higher serial correlation
d. Higher market beta

[14] I. Marsh and N. Niemer, "The Impact of Short Sales Restrictions" (working paper, Cass Business School, London, 2008).

EXAMPLE 30.12: FRM EXAM 2007—QUESTION 62

You are asked to estimate the exposure of a hedge fund to the S&P 500. Though the fund claims to mark to market weekly, it does not do so and merely marks to market once a month. The fund also does not tell investors that it simply holds an exchange-traded fund (ETF) indexed to the S&P 500. Because of the claims of the hedge fund, you decide to estimate the market exposure by regressing weekly returns of the fund on the weekly return of the S&P 500. Which of the following *correctly* describes a property of your regression estimates?

a. The intercept of your regression will be positive, showing that the fund has a positive alpha when estimated using an ordinary least squares (OLS) regression.
b. The beta will be misestimated because hedge fund exposures are nonlinear.
c. The beta of your regression will be one because the fund holds the S&P 500.
d. The beta of your regression will be zero because the fund returns are not synchronous with the S&P 500 returns.

30.5 DEALING WITH HEDGE FUND RISKS

Because of these risks, hedge funds need to be monitored closely. This starts with **due diligence**, which is the process of systematically investigating the fund before investing. On the operational side, this involves an analysis of the fund documents; of the key personnel (including background checks); of the fund service providers (administrator, prime broker, legal counsel, auditor); of the regulatory registration; and of the operations and valuation procedures. On the investment side, this involves an analysis of the investment strategy, of the risk factors, and of the risk control systems. Once a hedge fund manager is hired, some components of this due diligence process need to be verified periodically.

Without information about the positions, however, this process is rather incomplete. It is very difficult to detect style drift, for example, from historical returns. Because returns are typically provided at monthly intervals, structural breaks can generally be identified only after a few years.

30.5.1 Hedge Fund Transparency Issues

Hedge funds are generally reluctant to reveal information about their positions. This lack of transparency has serious disadvantages for investors.

Disclosure allows *risk monitoring* of the hedge fund, which is especially useful with active trading. This can help an investor avoid situations where the hedge fund manager unexpectedly increases leverage or changes style. Closer monitoring of the fund can also decrease the probability of fraud or misvaluation of assets.

Disclosure is also important for *risk aggregation*. The investor should know how the hedge fund interacts with other assets in the portfolio. Whether the hedge fund has a positive or negative correlation with the rest of the portfolio affects the total portfolio risk.

Example: Why Risk Aggregation?

Aggregation of positions is important to identify potential concentrations to individual names (companies). The story is told of a large pension fund that had allocated assets to outside managers investing in corporate bonds, growth equities, and value equities. In 2000, Enron was rated investment-grade and viewed as a growth stock, reflecting its high stock price of $90. The fund had positions in Enron corporate bonds, and in Enron stock through the growth manager.

As negative news unfolded the following year, the stock price fell to $15 by October 2001. Many saw this decline as a great opportunity to buy the stock. The pension fund's value managers started to buy the stock. As the same time, its other managers did not have the discipline to sell. By December 2001, the stock price had fallen to $0.03. The pension fund ended up with large holdings of Enron stock and bonds, and a huge loss due to its failure to identify this concentration risk.

Greater disclosure is often resisted on the grounds that it would disclose *proprietary information*, leading to the possibility of a third-party trading against the hedge fund. This threat, however, comes from the broker-dealer community, generally not from investors. If this is an issue, confidentiality agreements should prevent leakages of sensitive information. Hedge funds generally prefer to release such information to investors with no trading operations of their own, whether directly or through affiliates, who would not be able to profit from this information.

Another argument sometimes advanced is the *lack of investor sophistication*. In other words, disclosing positions would give too much information to investors who might not able to use it.

30.5.2 Solutions for Transparency

These arguments can be addressed with a number of solutions. The first consists of external risk measurement services. These firms have access to the individual positions of hedge funds, with the proper confidentiality agreements, and provide aggregate risk measures to investors. They release only aggregate information such as gross and net leverage, asset, industry, and geographic allocations, as well as factor exposures. This solves the risk aggregation problem.

Another solution is to go through a fund of funds that has position-level information. The fund of funds can use this information to monitor the managers and to provide aggregate statistics to the investors. Thus this approach solves both problems, risk monitoring and risk aggregation.

EXAMPLE 30.13: TRANSPARENCY

Investors should insist on learning about the positions of hedge funds because

a. They want to trade ahead of the hedge fund.
b. They do not understand the trading strategies behind the positions.
c. They want to aggregate the risk of hedge funds with the rest of their portfolio.
d. They receive the information from the prime broker anyway.

EXAMPLE 30.14: FRM EXAM 2009—QUESTION 8-8

Risk management of hedge funds has challenges not generally faced in traditional investment management companies. Which of the following statements are *correct* about hedge fund risk management?

I. Because hedge funds can hold long and short positions, and can use derivatives and leverage, their exposure to market risks can experience large and rapid changes that make it difficult to assess these exposures using only monthly returns.
II. Many hedge funds use over-the-counter derivatives, which are valued by models or quoted prices and often hold illiquid assets; as a result, the returns of these strategies generally exhibit much lower serial correlation than mutual fund returns.
III. For hedge fund strategies that use leverage to amplify returns and rely on their ability to move out of trades quickly when they turn against them, liquidity risk must be closely monitored and managed.
IV. Hedge fund returns are often similar to the return of a basket of exotic derivatives with nonlinear payoffs, and therefore assessing risk based on past performance can be misleading.

a. I, II, III, and IV
b. I, III, and IV
c. I and III
d. II and IV