ISMA CENTRE - THE BUSINESS SCHOOL OF THE FINANCIAL MARKETS

UNIVERSITY OF READING
ENGLAND

IFID Certificate Programme

Portfolio and Risk Management

Portfolio Management

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1. Overview

In this module on the IFID Certificate Programme we take a brief look at how the risks and the return on financial instruments net out and interact with each other when combined in an investment or trading portfolio.

We begin with a short discussion of two technical questions about portfolio return and risk:

- How do we calculate the **compounded annual growth rate** (CAGR) on an investment fund, taking into account any new cash coming into the fund or being paid out of it?

- What is relationship between the return and the risk on a portfolio[1]?

We then discuss how analysts go about assessing the investment performance of:

- **Active funds**, which seek to outperform (or **beat**) a specified market benchmark or index

- **Passive funds**, which simply aim to match (or track) the performance of an index

- **Long terms funds**, such as pension funds and life assurance companies, which simply aim to meet their future contractual payment obligations towards their members

[1] This question introduces Harry Markowitz's seminal work of the early 1950s, which began what is referred today as **Modern Portfolio Theory** (MPT).

Learning Objectives

By the end of this module, you will be able to:

1. Calculate the money-weighted rate of return on a portfolio and explain the difference between this and the internal rate of return
2. Calculate the compounded annual growth rate (CAGR) of a bond portfolio
3. Calculate the return and the risk on an asset portfolio given the risks on its individual components and their return correlations
4. Define the concept of the portfolio frontier and explain how asset correlations affect its shape
5. Explain how the Sharpe ratio is used to compare the performances of different portfolios and to identify optimal portfolios
6. Explain what is meant by the alpha and the beta coefficients of a bond index tracking portfolio
7. Define tracking error and explain its use in assessing the performance of a bond index tracking fund
8. Distinguish between a duration-weighted index tracking strategy and a beta-weighted index tracking strategy
9. Explain how multi-factor models may be used to tilt credit portfolios in search of index out-performance
10. Construct a synthetic fund which tracks benchmark index with a given duration using:

    - Bond futures
    - Interest swaps

    And explain the limitations of such strategies.

2. Return on a Fund

2.1. Internal Rate of Return

Calculating the total return of an investment portfolio over a given time period is a bit more complicated than calculating the horizon yield on a single bond, as we did in module Bond Pricing and Yield – Horizon Yield, because we need to factor out of the calculation any new money that may have been invested into the fund, or withdrawn from it, during the review period.

Example

The table below shows the market value of an open-ended fund at various dates during the quarterly review period 31 December – 31 March, together with the various payments and withdrawals that took place on the various dates.

Date	Fund market value Before cash flow[2]	Cash flow
31 Dec	250	
10 Feb	265	New money = 80
23 Feb	353	Distribution = -16
15 Mar	331	Withdrawal = -20
31 Mar	322	

Ideally, we should calculate the internal rate of return (IRR) on this fund over the period, a measure that takes both the size and the timing of all cash flows.

As we explained in module Time Value of Money – Internal Rate of Return, the IRR calculation is arrived at by a process of iteration. The table below demonstrates that the IRR for this fund over the review period is 9.917% (or **9.92%**, rounded) because when we discount all the cash flows at this rate we arrive at an NPV of zero.

Date	Days from Review	Fractional period From review date	Cash flow	NPV of cash flows Discounted @ R = 9.917%
31 Dec	0	0/90 = 0.0000	Initial valuation = 250	250.0000
10 Feb	41	41/90 = 0.4556	New Money = 80	$80 / (1 + R)^{0.4556}$ = 76.5420
23 Feb	54	54/90 = 0.6000	Distribution = -16	$-16 / (1 + R)^{0.6000}$ = -15.1014
15 Mar	74	74/90 = 0.8222	Withdrawal = -20	$-20 / (1 + R)^{0.8222}$ = -18.4922
31 Mar	90	90/90 = 1.0000	End valuation = -322	$-322 / (1 + R)^{1.0000}$ = 292.9484
NPV				**0.00**

Notice the signs of the cash flows:

- Positive for cash into the fund (including the initial valuation)
- Negative for cash out of the fund (including the terminal valuation)

[2] USD millions, including coupons earned.

2.2. Money-weighted Return

For a very active open-ended fund the IRR calculation could be rather computationally intensive and as a result many such funds calculate instead an approximation to the IRR, known as the **money-weighted return** (MWR).

The MWR methodology is best explained using the example of the fund on the previous page.

Date	Market value Before cash flow	Cash flow	Market value After cash flow	Sub-period relative
31 Dec	250		250	
10 Feb	265	New Money = 80	345	265 / 250 = 1.06000
23 Feb	353	Distribution = -16	337	353 / 345 = 1.02319
15 Mar	331	Withdrawal = -20	311	331 / 337 = 0.98220
31 Mar	322		322	322 / 311 = 1.03537
Product of sub-period relatives				**1.10295**

To calculate the MWR we proceed as follows:

1. Calculate the return achieved by the fund in each sub-period during which there was no net cash flow: in the last column of the table we calculate the relative value of the fund for each sub-period

2. Calculate the **geometric average** of the sub-period relatives:

   Product of sub-period relatives
   = 1.06000 x 1.02319 x 0.98220 x 1.03537
   = 1.10295

   MWR = $[(\sqrt[4]{1.10295}) -1] \times 4$
   = 0.09920, or **9.92%** rounded.

The calculation of MWR is easier than IRR, but notice the following:

The market value of the fund must be known each time there is a cash flow coming into or out of the fund.

This is not a problem for funds that are revalued daily, but it may be an additional burden for funds that are revalued at review dates only[3].

2.3. Average Return

Notice how when we calculated the MWR in the example above, we did so using a geometric and not an arithmetic average.

Fund performance is typically expressed as a percentage return per annum and it is important to understand that this is also the correct way of annualising returns achieved by a fund over a sequence of shorter time periods.

Example

The table below shows the performance of a fund over a number of successive revaluation periods.

Period	Period Return
1	9.92%
2	7.10%
3	-6.53%
4	4.01%

Arithmetic return
Suppose each period in the table corresponds to one calendar quarter. Then the arithmetic cumulative return of the fund for the whole year would be:

9.92 + 7.10 - 6.53 + 4.01 **= 18.50%**

This calculation is misleading because it suggests that $100 invested in this fund at the start of the year would grow to $118.50 by the end of the year, whereas in fact as the table below shows the terminal value of $100 is only $114.45.

[3] An even simpler but less accurate method devised for such cases is known as the **time-weighted return** (TWR) and for reference purposes only we show below the formula for TWR, but please note:

The TWR method of calculating fund return lies outside the scope of the IFID Certificate syllabus.

$$\text{Time-weighted return} = \left(\frac{FV - \Sigma C_t}{\Sigma (C_t \times L_t)} \right) \times 100$$

Where:
FV = Fund value at the end date
PV = Fund value at the base date
C_t = Value of cash flow into (+) or out of (-) the fund at time t, including PV which is given a +ve sign
L_t = Length of time cash flow t is in the fund, as a fraction of the review period

The numerator in the TWR formula is the fund's earnings during the review period, net of cash inflows and outflows, while the denominator is the time-weighted average of the fund's capital, where the weights are the proportion of time that each cash flow has been in the fund during the review period.

TWR is easiest to implement because it does not require the fund to be revalued each time there is a cash flow coming in or out of the fund. However, the return estimate can sometimes be significantly different from what would be obtained from a proper IRR calculation.

The reason for this disparity is that an arithmetic return calculation fails to take into account any scaling effects:

- If the fund generates a positive return during a certain period then the actual market value of the fund increases, so a given return in the following period will result in a larger gain or loss in cash terms
- If the fund generates a negative return during a period then the value of the fund is reduced, so the same return the following period will translate into smaller absolute gains or losses

Geometric return

Period	Period Return	Return Relative	Cumulative Return relative	Value of $100 Invested in the fund
1	9.92%	1.0992	= 1.0992	109.92
2	7.10%	1.0710	1.0992 x 1.0710 = 1.1772	117.72
3	-6.53%	0.9347	1.1772 x 0.9347 = 1.1003	110.03
4	4.01%	1.0401	1.1003 x 1.0401 = 1.1445	114.45

The correct way to annualise period returns is to multiply the period relative returns, as shown in the table. The cumulative return relative over the 4 periods is 1.1445, which implies an increase of 14.45% for the whole year.

The same considerations apply when calculating average annual return achieved by a fund over longer periods – the so-called **compounded average growth rate** (**CAGR**).

Suppose the table above refers to annual returns achieved by a fund over 4 years. The arithmetic average annual return would be 4.625% [= (9.92 + 7.10 - 6.53 + 4.01) / 4]. Again, this implies that $100 invested in the fund at an annually compounded rate of 4.625% over 4 years would grow to 118.50%, which is not true.

The CAGR is:

$= (\sqrt[4]{1.1445}) - 1$
$= 0.03432$ or **3.432**%

This implies that $100 invested in this fund for 4 years would generate:

$100 \times (1 + 03432)^4 =$ **114.45**, which is correct!

CAGR = $\sqrt[Y]{\prod (PR_t / PR_{t-1})} - 1$ **for t = 1...N**

Where:
Y = Number of years or fractions in the review period
N = Number of valuation periods in the sample
PR_t = Price relative between period t and period t-1 (i.e. $Price_t / Price_{t-1}$)
$\prod$ = Product of terms PR_t / PR_{t-1} for t = 1...N

3. Portfolio Return and Risk

In this section we explore the relationship between the return on a portfolio and its risk, where risk is measured as the standard deviation of annualised total return, as calculated in the previous section.

Consider a simple portfolio consisting of just two securities, A and B, whose return and risk characteristics are summarised in the table below.

Security	**A**	**B**
Total return (% per annum)	2.00	6.00
Risk (% per annum)	10.00	20.00

- If you were 100% invested in security A then your portfolio would have a total return of 2% and a risk of 10%

- If you were 100% invested in security B then your portfolio would have a total return of 6% and a risk of 20%

? What would be the risk and the return on a 50/50 portfolio – i.e one where you allocate 50% of your capital to security A and 50% to security B?

3.1. Portfolio Return

The total return on a portfolio is a weighted average of the total return on each component asset.

The weights in the average are the proportion of the total portfolio, by market value, that is committed to each asset. For example, the average return on a 50/50 portfolio would be:

Portfolio return:
= 0.5 x Return on A (2%) + 0.5 x Return on B (6%)
= **4.00%**

Portfolio return $= (w_1 \times R\%_1) + (w_2 \times R\%_2) + \ldots + (w_n \times R\%_n)$

$$= \Sigma (w_i \times R\%_i)$$

for $i = 1 \ldots N$

Where:
N = Number of instruments in the portfolio
w_i = Proportion of the portfolio value committed to instrument i ($\Sigma w_i = 1.0$)
$R\%_i$ = Total return on instrument i

3.2. Portfolio Risk

The risk on the portfolio does not follow the same simple rule as its return. For a two-asset portfolio of securities **A** and **B**:

Portfolio risk

$$= \sqrt{ (w_A \times \sigma_A)^2 + (w_B \times \sigma_B)^2 + (2 \times w_A \times w_B \times \sigma_A \times \sigma_B \times \rho_{AB}) }$$

Where:

w_A = Proportion of the portfolio invested in asset A - the ' weight' of A
w_B = Proportion of the portfolio invested in asset B - the ' weight' of B
ρ_{AB} = Standard deviation ('risk') of the return on asset A (in percent)
σ_B = Standard deviation of the return on asset B
σ_A = Correlation coefficient of the returns on assets A and B

In our case, if we assume initially that the return on the two assets are uncorrelated:

Portfolio risk
$= \sqrt{ (0.5 \times 10.0)^2 + (0.5 \times 20.0)^2 + (2 \times 0.5 \times 0.5 \times 10.0 \times 20.0 \times 0.0) }$
= 11.2%

Portfolio Risk[4] $= \sqrt{ \Sigma (w_i \times \sigma_i)^2 + \Sigma (2 \times w_i \times w_j \times \sigma_i \times \sigma_j \times \rho_{ij}) }$

for i = 1…n, j = 1…n, i ≠ j

Exercise
Risk and the return on a 60/40 portfolio

The table below shows the risk and return characteristics of the two securities we saw earlier, whose performances are uncorrelated:

Security	A	B
Total return (% per annum)	2.00	6.00
Risk (% per annum)	10.00	20.00

What is the return and the risk on a portfolio in which you allocate 40% of your capital to security A and 60% to security B? Enter your result in each box below, in percent to 2 decimal places.

a) Portfolio return (%)

b) Portfolio risk (%)

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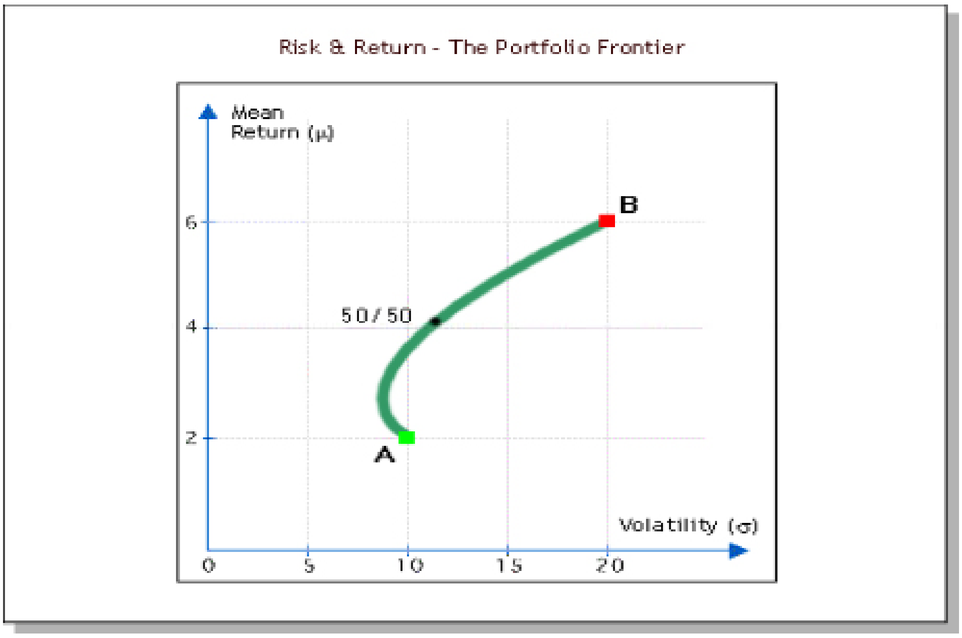
[4] This formula represents the standard deviation of a linear combination of n random variables and is not too difficult to derive from first principles. However, the derivation of this formula lies outside the scope of the IFID Certificate syllabus.

3.3. Portfolio Frontier

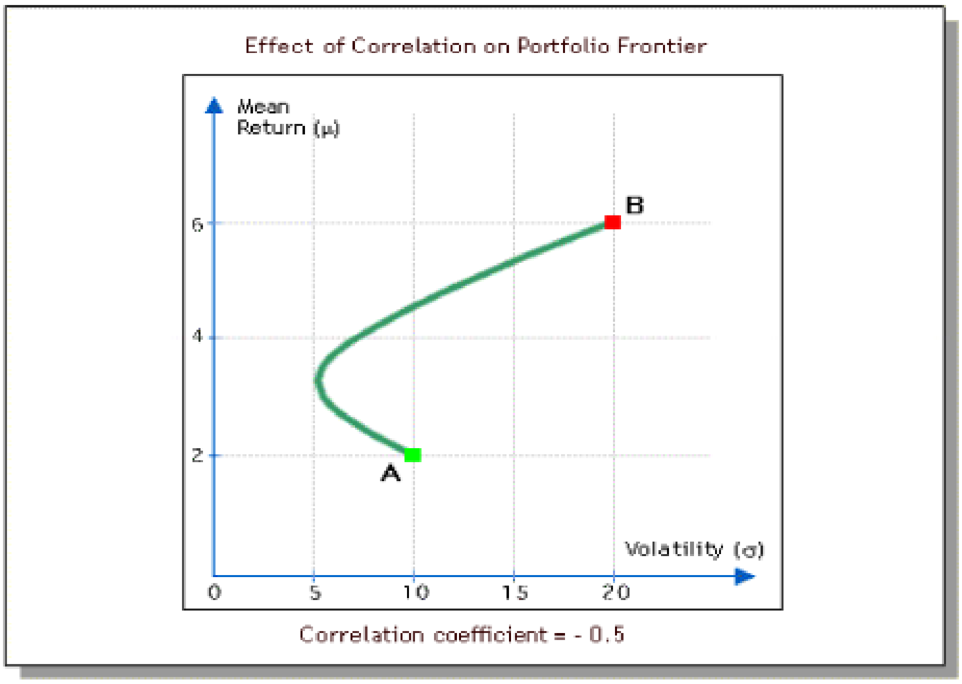
Both the risk and return on the portfolio are a function of the proportion of capital allocated to each asset - the portfolio weightings. The figure below shows the risk/return characteristics of all possible portfolio combinations involving the two securities in our earlier example – the so-called **portfolio frontier**.



Starting from point A, where we are 100% invested in security A, as we vary the mix in favour of security B, we seem to get - initially at least - a proportionately higher portfolio return for the additional risk.

3.4. Impact of Correlation

The shape of the portfolio frontier depends on the degree of correlation between the component assets. The more correlated are the returns on the individual assets, the less of their risk that can be diversified and the straighter will be the portfolio frontier.



In the example above, if the two instruments had perfect negative correlation, then it should be possible to construct a **risk-free portfolio** - i.e. one which, like a fixed income security, displays no volatility of returns[5].

4. Active Funds

Now that we understand how portfolio returns are calculated, we can examine how consulting companies that specialise in measuring fund performance[6] assess different types of investment fund and in this section we focus on active portfolios – i.e. those that seek to outperform a specified market benchmark or index, as defined in the fund's policy document.

Active fund management is about betting on asset classes, sectors or individual securities which the fund manager believes will outperform their benchmark, by 'tilting the fund' or going 'overweight' in those sectors relative to their benchmark.

Thus, if a manager believes that high-yielding corporate bonds will outperform other bonds in the coming quarter, she may decide to go overweight in those bonds, by allocating a higher percentage of the fund to them than is specified in her benchmark. If those bonds do indeed outperform, then the fund will reap the benefit of having been overweight in them.

The performance of investment funds is closely monitored by their sponsors as well as by independent financial advisors and one or two years of lack-lustre performance by a fund can result in a substantial contraction in its size, as clients cash out their units.

How is the performance of an active fund assessed?

[5] This idea was used by Fischer Black and Myron Scholes in 1973 to develop their option pricing model. Their risk-free portfolio consisted of a combination of:

- Short a call option
- Long the delta amount of the underlying asset
- An amount of funding

As we saw in module Options Pricing and Risks - Binomial Model, the option and the underlying asset are risky on their own, but when combined in the right mix together with a funding instrument, they can result in a risk-free portfolio. Since we know the funding rate and we also know the price of the underlying instrument, we can therefore derive the option price implied this risk-free portfolio.

[6] Two of the largest firms in this business are:

- Russell/Mellon CAPS, which monitors some 200 asset managers and 900 pension funds in Europe (http://www.russellmelloncaps.com)

- The WM Company, a subsidiary of Deutsche Bank, which measures the performance of ¾ of UK pension funds and 95% of Dutch pension funds. (http://www.wmcompany.com).

Fund policy
Brief description of the type of information that is typically found in a fund's policy document

The policy document of an active investment fund typically specifies:

1. The broad asset class (or classes) and geographical sector(s) that the fund will target, as well as its broad investment goals. Typical goals might be:
    - To provide stable income while preserving capital values (for cautious investors)
    - To provide stable and growing income with moderate capital growth (for balanced investors)
    - To provide strong capital growth (for more adventurous investors)
2. The fund's return objectives, which will be the basis on which its investment performance will be assessed. Typical return objectives are to outperform:
    - The return on a pre-defined **benchmark index** or specified benchmark portfolio[7] – e.g. the Lehman Brothers USD Eurobond index
    - Or simply other **peer funds** with similar investment goals (in which cases the fund's benchmark is implied in the average asset and sector allocations achieved by the universe of peer funds)
3. The various **constraints** placed upon the fund manager, in terms of:
    - Types of acceptable securities and financial instruments – e.g. only listed securities or derivatives as well
    - The levels of risk allowed – e.g. minimum credit rating, issue size and liquidity of any securities held; maximum allowable holdings in each security; fund **gearing** levels, etc.

[7] For so-called **balanced funds**, the fund sponsors typically specify a **composite benchmark**, like the example below, which is made up of a combination of different market indices:

Index Name	**Weighting**
S&P 500	50%
Lehman Brothers Aggregate USD Bond Index	30%
Salomon Brothers Certificate of Deposit Index	20%
-	**100%**

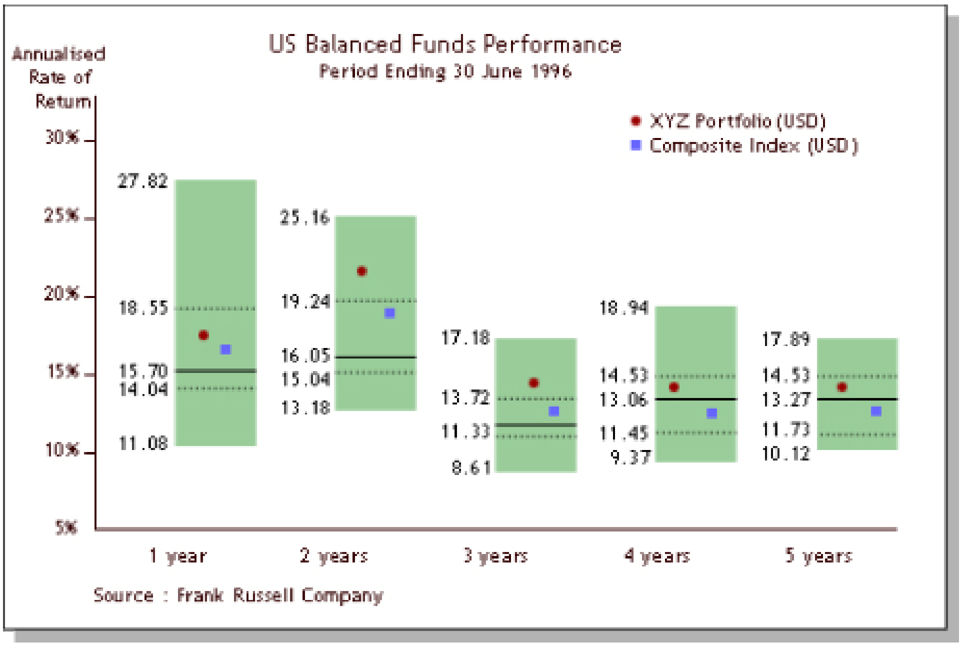
4.1. Return League Tables

Fund performance is rarely measured in absolute terms. The manager of a portfolio that is meant to beat the performance a bond index might be looked upon very favourably if his portfolio only loses 5%, when the rest of the market lost 8%.

The simplest way of assessing performance is a simple **league table** that ranks funds with similar goals according to the returns achieved over different historical periods:

- Other the past month
- Over the past quarter
- 1, 3 and 5 years to date
- Since the funds' inception

Some league tables attempt to give more information than just raw returns. The figure below illustrates one way of viewing the performance of a specific fund relative to its benchmark and the universe of peer funds.



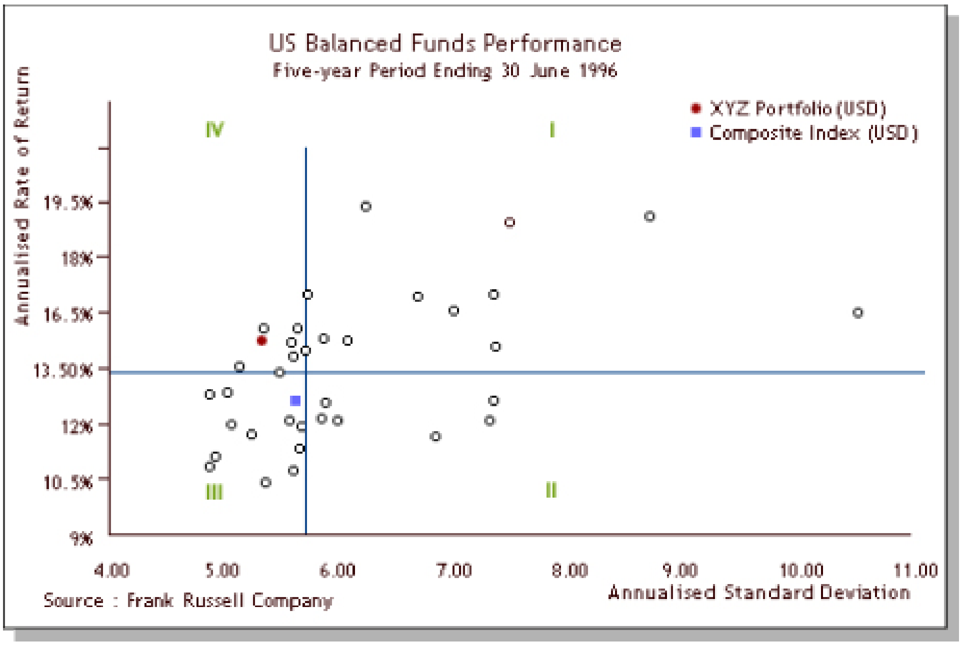
Each bar in the figure shows the range of performance among participants over a given period. The solid line across each bar locates the median fund and the dashed lines are the 25 percentiles. Notice the following:

- The worse performers tend to be more bunched together than the better performers
- Performance ranges tend to narrow down over the longer review periods: in the long run the returns of most funds, year in year out, tend to average out!

4.2. Risk-adjusted Return

Higher return normally implies more risk.

Measuring the return on a fund without regard to the risks being taken to achieve it makes for an incomplete analysis. The figure below places each fund on a risk/return map.



The horizontal cross-hair in the chart locates the median fund in terms of the average return achieved over the review period and the vertical cross-hair locates the median fund in terms of its risk, as measured by the standard deviation of its return. Funds in the north-west quadrant of this chart are clearly preferable to those in the south-east.

A commonly used measure of risk-adjusted return is the **Sharpe ratio**, which we encountered in module Credit Analysis – High Yielding Bonds.

$$\textbf{Sharpe ratio} = \frac{\textbf{Excess portfolio return}}{\textbf{Portfolio risk}}$$

$$= (R - R_f) / \sigma$$

Where:
R = Total portfolio return over the review period
R_f = Risk-free rate; ($R - R_f$) = Portfolio **excess return** over the risk-free rate
σ = Standard deviation of the portfolio's historic return

Note that the return used in these formulas is not just the absolute return on the fund but its excess return over the risk-free rate, also known as the **risk premium**. This is typically calculated as the portfolio's return over and above the yield on Treasury bills[8].

[8] Some fund performance assessment services rank funds in terms of a related measure known as the **coefficient of variation**:

Coefficient of variation = σ / R

This measure takes the fund's absolute return rather than its excess return. Although typically funds that score highly on the Sharpe ratio also tend to have low coefficients of variation and vice-versa, from a finance theory point of view the Sharpe ratio is considered a more accurate measure, as we shall explain in the next section. But please note:

In the next section we shall explain in more detail how we calculate the total return on a portfolio and we also show how the Sharpe ratio is effectively a device for identifying optimal portfolios.

5. Efficient and Optimal Portfolios

In the previous section we explained how analysts use the Sharpe ratio as a way of assessing the historic risk-adjusted performance of active portfolios. The Sharpe ratio can also be used as a tool for determining what asset combinations offer the investor the best return for the amount of risk taken – i.e. for **portfolio optimisation** – and in this section we briefly explain the theory behind such a claim.

So far in this module we have focused mainly on the assessment of historic portfolio performance but you should note that in the context of portfolio selection and optimisation, references to return and risk should be interpreted to mean expected future returns and risks, not historic ones. Historic performance may provide a guide to future performance but the two are of course not identical.

? Doesn't the choice of the portfolio that offers the investor the best risk-return combination not depend on the investor's risk appetite?

The Sharpe ratio method seems to suggest that it is possible to identify an optimal portfolio without reference to the investor's risk appetite and in this section we explain how this is so. Let's begin by making an important distinction between an **efficient portfolio** and an **optimal portfolio**.

5.1. Efficient Portfolios

In section *Portfolio Return and Risk* we plotted a portfolio frontier involving different combinations of just two risky securities. In practice of course, your portfolio will consist of many more securities. By varying the weighting of each security held, it is possible construct a whole universe of alternative portfolios, each with its unique combination of expected risk and return.

Efficient portfolio is a portfolio that offers:

- Either the highest possible expected return for a given level of risk
- Or the lowest possible amount of expected risk for a given return

Efficient frontier is the curve representing all the possible efficient portfolios.

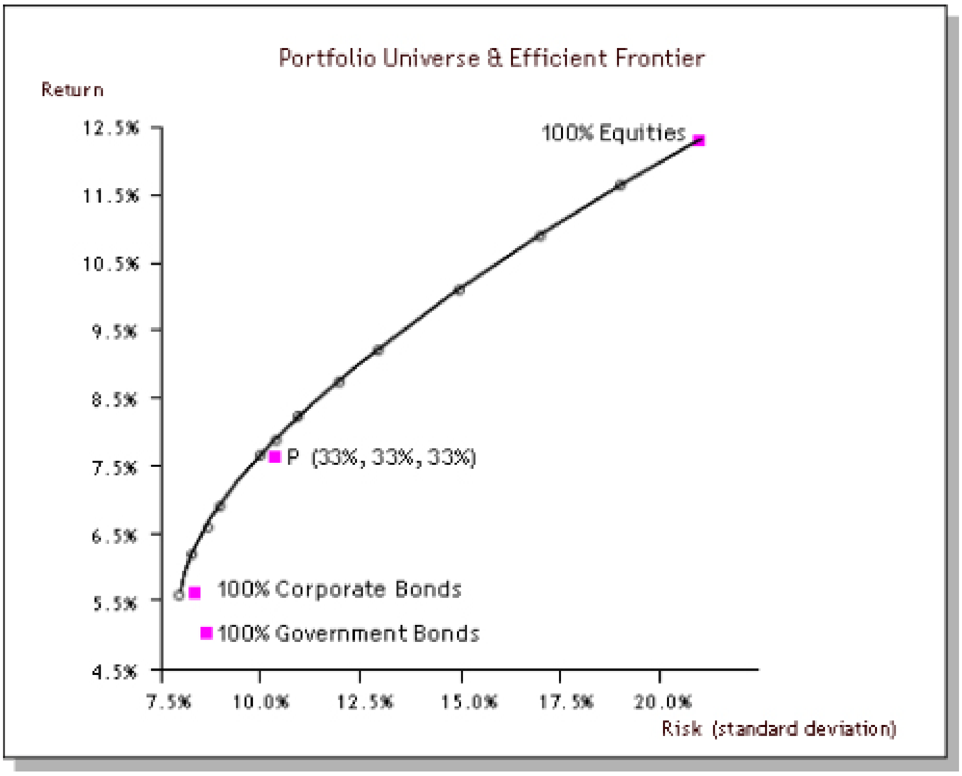
Also known as: **Markowitz frontier**

The figure below shows the average annual return and risk characteristics of 3 major US asset classes between 1926 and 1993:

- Government bonds
- Corporate bonds
- Listed equities

The figure below shows what the efficient frontier involving all possible combinations of these asset classes would look like, assuming that these assets will display the same historic risk, returns and return correlations over the investment horizon period.

You are not required to know the coefficient of variation for the IFID Certificate exam, or to explain why the Sharpe ratio is a better measure of risk-adjusted portfolio return.



We have also marked the risk-return profile of one portfolio (labelled P), where we invest in these 3 assets in equal parts. Compared with investing exclusively in corporate bonds, P seems to offer the prospect of a significantly higher return for a relatively small amount of additional risk. However, it appears from the figure that there are other more efficient portfolio combinations possible (to the north-west of point P) which could yield either a higher return for the same amount of risk or a lower risk for the same return than P. Therefore, P is not an efficient portfolio.

Asset allocations behind efficient frontier

Basic data:

Asset class	**Mean return**	**Standard deviation**	**Correlations**		
Government bonds	5.0%	8.7%	1.000	+0.832	+0.392
Corporate bonds	5.4%	8.4%	+0.832	1.000	+0.114
Listed equities	12.3%	20.5%	+0.392	+0.114	1.000

The table below shows the range of portfolio allocations used to generate the efficient frontier above - i.e. all these portfolios achieve the lowest risk for a given level of return. The figures were calculated on the assumption that the investor cannot short-sell any of the assets.

Asset Allocations			Portfolio characteristics	
Govt. bonds	**Corp. bonds**	**Equities**	**Return**	**Risk**
35.2%	61.6%	3.2%	5.6%	8.0%
21.5%	67.5%	11.1%	6.2%	8.4%
12.9%	71.2%	15.8%	6.6%	8.7%
6.4%	74.0%	19.6%	6.9%	9.0%
0.0%	69.6%	30.4%	7.6%	10.0%
0.0%	60.8%	39.2%	8.2%	11.0%
0.0%	53.1%	46.9%	8.7%	12.0%
0.0%	46.0%	54.0%	9.2%	13.0%
0.0%	32.9%	67.1%	10.1%	15.0%
0.0%	20.6%	79.4%	10.9%	17.0%
0.0%	8.7%	91.3%	11.7%	19.0%
0.0%	0.0%	100.0%	12.3%	21.0%

The process of arriving at an efficient portfolio involves a technique technique known as **quadratic optimisation**, an explanation of which is beyond the scope of the IFID Certificate programme.

5.2. Optimal Portfolios

Rational investors obviously prefer efficient to inefficient portfolios – i.e. those which lie on the efficiency frontier, rather than underneath it. However, the figure on the previous page seems to suggest that there may be a whole range of efficient portfolios to choose from rather than an **optimal portfolio** - i.e. one that should be chosen by all investors. Each investor would choose a different efficient portfolio, depending on their individual risk appetite:

- Risk-averse investors would choose asset combinations that produce portfolios which would lie towards the bottom-left of the efficient frontier

- Investors with larger risk appetite - or risk seekers – would choose portfolios along the top-right of the frontier

However, it turns out that once we introduce the possibility of investing in a risk-free asset as well, we can in fact talk about an optimal portfolio.

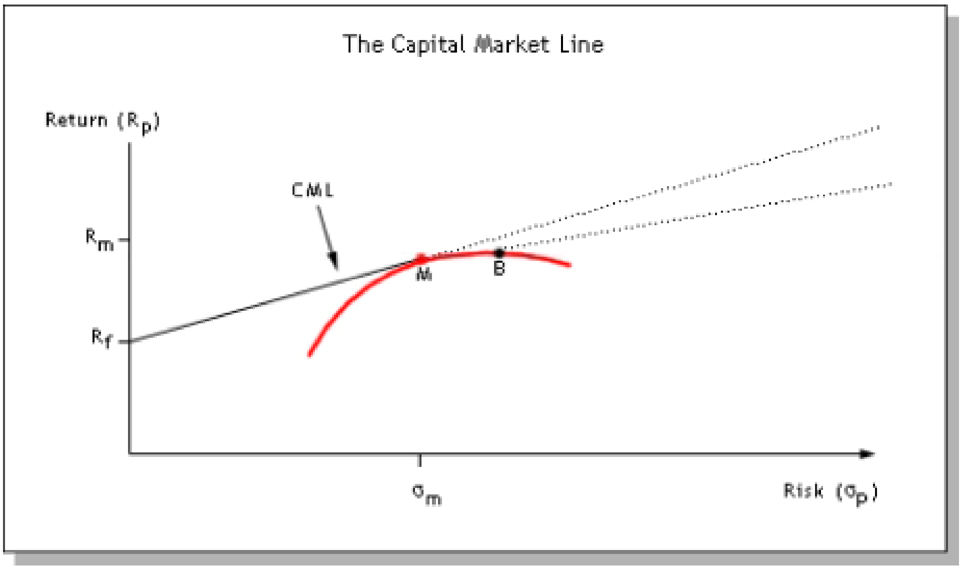
Optimal portfolio

- The portfolio of risky assets that would be selected by all rational investors, no matter what their risk preferences (assuming that they all agree on the expected return and risk of each component asset)

- The portfolio with the highest Sharpe ratio

These powerful statements are best demonstrated by looking at the figure below. On the figure we show R_f, which is the rate of interest on the risk-free asset - the risk-free rate. By assumption, its standard deviation is zero. We also identify M as that efficient portfolio of risky assets which is also optimal. This portfolio lies on the straight line R_fM, known as the **capital market line** (CML), which is tangent to the efficient frontier at point M.

The CML shows all the combinations of return and risk that can be achieved by investing different percentages of capital in either the risk-free asset or in portfolio M.



To prove that portfolio M is indeed the optimal portfolio, we need to demonstrate that:

- The CML is a straight line up to point M and investors can position themselves anywhere along the CML by combining varying proportions of portfolio M with an investment in the risk-free asset
- Therefore the CML becomes the new efficient frontier and M is the only portfolio which makes that possible
- Portfolio M is the one with the highest Sharpe ratio

All this is indeed the case and the section below gives you a formal proof of these statements, but please note:

This information is for your reference only and you are not required for the IFID syllabus to explain the derivation of the Sharpe ratio as a method of selecting the optimal portfolio.

Proof of the Sharpe ratio – optimal portfolio relationship

Structure of the CML

Using the formulas for portfolio risk and return that we developed in section *Portfolio Return and Risk,* we can derive the equation for the CML as:

$$R_p = R_f + (R_m - R_f) / \sigma_m \times \sigma_p$$

Where:
R_p = Return on a portfolio combining risky assets M and a risk-free asset
R_f = Return on risk-free asset (the risk-free rate)
R_m = Return on the portfolio of risky assets M
w = Proportion of the portfolio invested in M

Deriving the CML equation

The return on a portfolio that combines M and the risk-free asset is given by:

$$R_p = (1 - w) \times R_f + w \times R_m$$

The risk on that same portfolio is:

$$\sigma_p = \sqrt{[\ \{(1 - w) \times \sigma_f\}^2 + (w \times \sigma_m)^2 + \{2 \times (1 - w) \times w \times \sigma_f \times \sigma_m \times \rho_{fm}\}\ ]}$$

Where:
σ_p = Risk on the portfolio combining risky assets M and a risk-free asset
σ_f = Risk on the risk-free asset
σ_m = Risk on the portfolio of risky assets M
ρ_{fm} = Correlation of returns between the portfolio of risky asset and the risk-free asset.

Since by assumption $\sigma_f = 0$ and $\rho_{fm} = 0$, the portfolio risk formula reduces to:

$$\sigma_p = \sqrt{(w \times \sigma_m)^2}$$
$$= w \times \sigma_m$$

In other words, the risk on the portfolio is proportional to the percentage of the fund allocated to M.

From this last equation $w = \sigma_p / \sigma_m$. Substituting for w in the first equation above (and simplifying) we obtain the formula for the CML as:

$$\mathbf{R_p = R_f + (R_m - R_f) / \sigma_m \times \sigma_p}$$

The CML equation indicates that, for any fund that combines a mixture of the optimal portfolio M and the risk-free asset, the total return on that portfolio will be a function of just two components:

- The pure **price of waiting**, as represented by R_f
- The amount of risk on the portfolio, σ_p

The CML equation effectively states that any excess return on a portfolio must be paid for by taking on proportionately higher risk. The slope of this line, $(R_m - R_f) / \sigma_m$, is referred to as the **price of risk**.

Portfolio return = Price of waiting + Price of risk x Portfolio of risk

The CML describes a new efficient frontier that is attainable when you can invest in the risk-free asset, as well as in the risky portfolio M. Now you can see why M in the figure above, where the CML is tangent to the old efficient frontier, is the optimal portfolio: combining the risk-free asset with any portfolio other than M would produce a less efficient frontier.

Whether the CML extends as a straight line beyond point M depends on whether or not it is possible to borrow funds in order to create leveraged portfolios:

- If no borrowing is possible, then the CML curves along the old frontier to the right of point M

- If borrowing is possible at the risk-free rate, then the CML can extend beyond M as a straight line

- If borrowing is allowed, but at a higher rate than the risk-free rate, then the efficient frontier becomes a straight line again beyond point B but with a gentler slope, indicating a lower excess return-to-risk ratio

As you can see from the equation for the CML, the Sharpe ratio is the slope of that line. Finding the optimal portfolio of risky assets is therefore a matter of locating the point M on the efficiency frontier which maximises this ratio.

Optimal portfolio = Portfolio with the highest Sharpe ratio.

The idea is that investors will select the portfolio with the highest Sharpe ratio and combine this with varying amounts of the risk-free asset in order to achieve their required risk-return mix.

6. Case Study: Hedge Funds

6.1. What are They?

Hedge funds have become an important fund sector since the early 1990s and today there are more than 3,000 such companies with more than USD 400 billion of capital under management. The growth in this sector has averaged nearly 40% per annum in recent years and therefore before leaving the topic of active fund management it is worth taking a brief look at this sector.

Private investment vehicles specially designed for managing funds of unregistered (in the US **SEC-accredited**) investors.

Legally, a hedge funds typically takes the form of a limited-liability partnership or company that is open only to certain type of investor. In other words, it is not a collective investment vehicle like a mutual fund and its shares or participation certificates are not normally available for purchase by the public through a stock exchange. In the US and elsewhere hedge funds are only allowed to solicit and accept funds from certain types of investors (SEC-accredited), who can demonstrate a sufficient level of net worth.

Characteristics of hedge fund investments

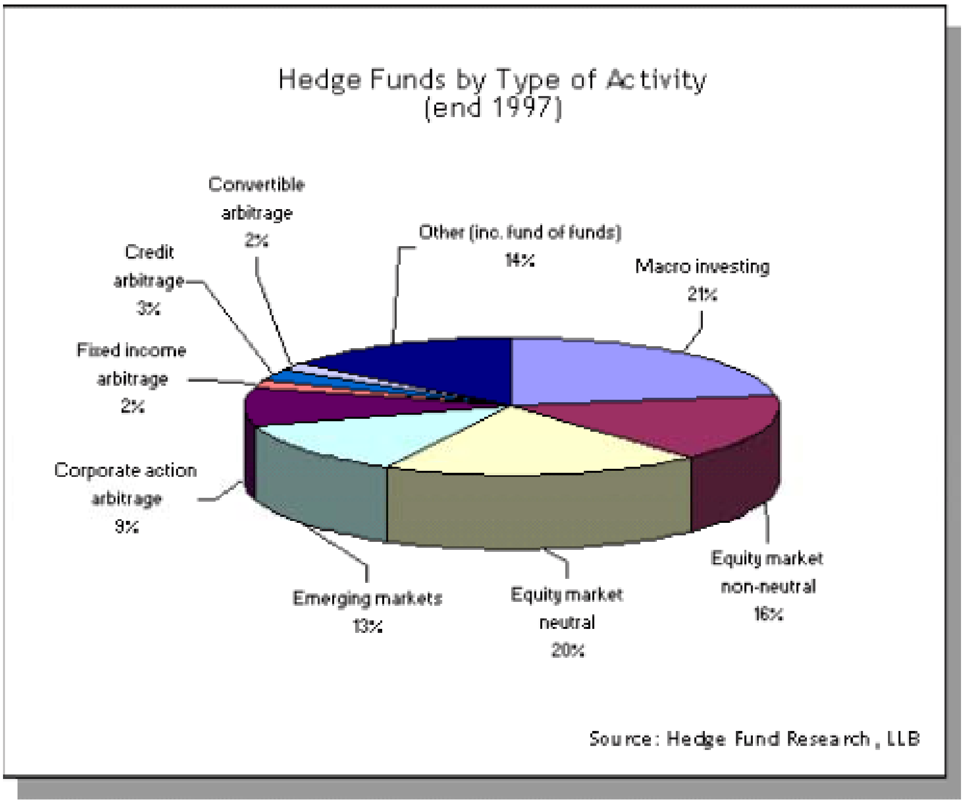
- Large minimum investment amounts required
- Include minimum lock-up periods of client money and also **holdover provisions** of some of that money, following an unwinding, to cover any residual obligations that the fund may have entered into
- Less transparent financial reporting than on other collective investment vehicles
- Funds have the freedom to:
  - Set up short as well as long positions in securities
  - Create leveraged or unleveraged positions
  - Use any cash and/or derivative instruments in any currency
- Fund manager typically earns annual management fee of 1-2% of assets under management plus 10-20% performance fee (subject to minimum **hurdle** and **water-mark** rates)

6.2. Types

Any private company that manages the assets of high net worth individuals classifies as a hedge fund and there is hardly any type of market activity that this sector of the market as a whole will not engage in. Indeed, a large percentage of hedge funds have been set up by senior traders with successful track records at investment banks or commodity trading firms, who decide to become business entrepreneurs by making their expertise available to private clients, in exchange for higher percentage participations in the profits of the operation[9].

If there is one common theme that runs among most hedge fund activities, that is their taking of spread, rather than outright, positions on related markets – hence their name. Very often such positions are highly leveraged.

The figure below shows the composition of this sector by different types of trading activity.



[9] One of the interesting responses by investment banks to this talent migration out of their dealing rooms has been to offer **prime brokerage** services to ex-employees who now head successful hedge funds. Prime brokerage services include:

- Settlement and custodian services of securities traded by the hedge fund
- Repo and margin financing of long and short positions
- Structuring of synthetic positions using OTC derivatives
- Provision of market information, position keeping, risk management and client accounting systems

Some banks even include the leasing of office space among their prime brokerage services – in other words, if you can't keep under your payroll, turn them into your high value-added clients!

Type classification

- **Macro investing**
  This is still the largest part of the market and funds under this category tend to take positions to profit from either absolute movements in interest rates, currency rates, equity markets or commodity prices, as a result of macroeconomic changes in the world economy or in individual OECD economies, or from relative movements in such key rates between different economies - for example, George Soros' Quantum Fund which took very large positions on sterling's suspension from the ERM in 1997, and Long Term Capital Management (LTCM) which took spread positions on European Union rates convergence in 1999 (see modules Bond Futures – Exercise 3 Question 8 and Interest Rate Swaps – The Swap Spread).

- **Equity markets**:

  - **Non market-neutral** (or **non-hedged**)
    Funds in this sector enter into outright positions in individual stocks or baskets of stocks. Many such funds tend to be specialists with long experience in specific industries and therefore a good understanding of the risks and the success factors behind the equities of individual companies operating in their industry.

  - **Market neutral** (or **hedged**)
    Funds in this sector tend to engage in spread trading, or trading the cash equity against the single-stock futures or index futures.

- **Emerging markets**
  As the name suggest, funds operating in this sector tend to rely on their specialist knowledge of the economic and political circumstances of individual emerging markets. The types of strategy that they follow include taking positions in either fixed income and equity instruments, in many cases non market neutral.

- **Corporate action arbitrage**
  Funds in this sector tend to engage in the buying and/or short-selling of equities and bonds whose prices are expected to move as a result of anticipated announcements of financial results, mergers, acquisitions, debt reschedulings and other types of corporate action.

- **Fixed income arbitrage**
  Still a small sector that performs many of the strategies in cash and derivatives that we covered in this syllabus, such as:

  - Yield spread and barbell strategies that we described in module Outright and Spread Trading

  - Spread trading of volatility in the interest rate caps & floors market against volatility in the swaptions market (see module Interest Rate Options – Caps, Floors and Collars and Swaptions)

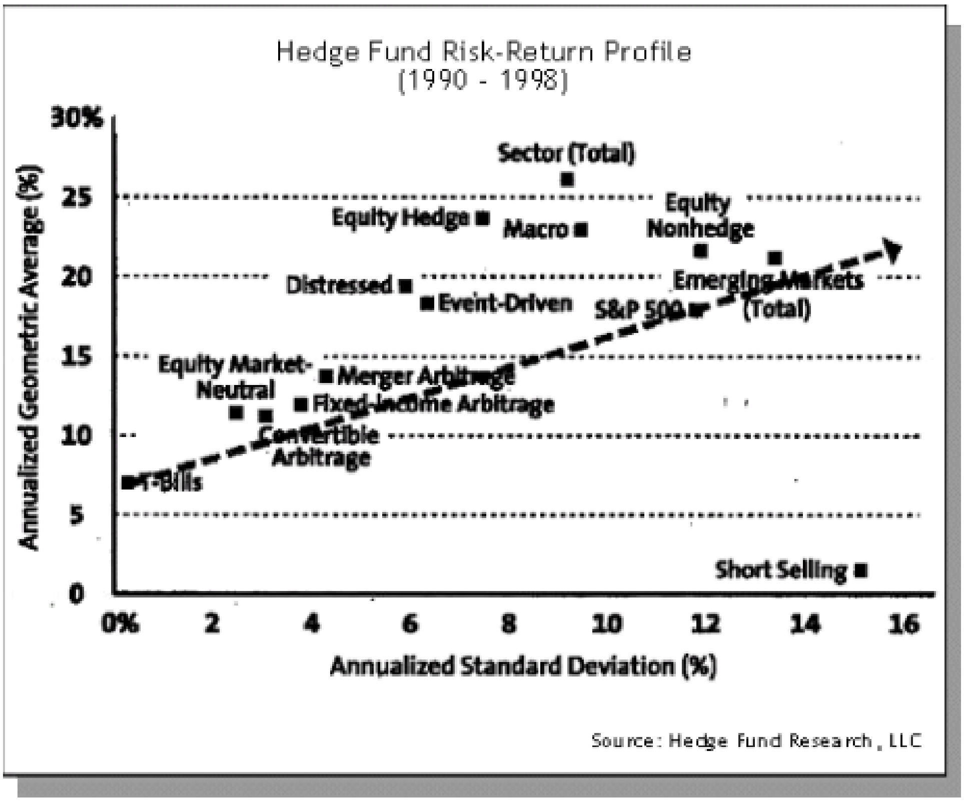
- **Convertible arbitrage**
  A small sector of the market that attracted a great deal of interest in the late 1990s but has since become rather subdued. This sector performs arbitrage of convertibles against equities (and now also against credit derivatives) of the types that we explained in module Convertible Bonds - Strategies

- **Credit arbitrage**
  A small but rapidly growing part of the market and funds in this sector engage in the types of arbitrage between asset swaps and credit default swaps that we analysed in module Credit Derivatives – Exercise 2. They also enter into so-called **capital structure arbitrage** that involves trading the CDS of a name against its equity. This sector also includes funds that take positions in the equity and the debt of distressed companies in the expectation of successful work-outs with their creditors.

- **Fund of funds**
  This is a relatively new sector for which figures are rather difficult to obtain, but consists of funds that invest client money in a portfolio of equity and participation certificates of individual hedge funds, chosen according to criteria such as for example their historic Sharpe ratios. Many of these have been set up by people who previously worked for consulting companies that specialise in measuring the performance of traditional active investment funds.

6.3. Performance

The figure below compares the average return and risk performance of different types of hedge fund in the US over the period 1990 – 1998 against the risk-free rate as represented by the yield on T-bills and also against the performance of the S&P 500 index over the same period.



Notice:

- Funds that specialised in short-selling strategies had an abysmal performance during the decade of the 1990s, during which the equity markets displayed much "excessive exuberance"!

- Emerging markets funds have produced higher returns but at the cost of higher risk, so their Sharpe ratios are no better than that on the S&P 500

- By-and-large, the hedge fund sector as a whole had higher Sharpe ratios than that on the S&P 500 - hence the rationale for the fund-of-funds investment strategy

7. Passive Portfolios

Portfolios that simply seek to match (or track) a specified market benchmark or index.

Also known as: **Index trackers, Index funds, Passive funds**

Fund performance tables show that very few funds are able to systematically stay at the top of their league or even beat their stated benchmark over longer periods.

? Why hire expensive fund managers if most of the time their performance is mediocre? Why not just 'buy the benchmark'?

Although the concept of an index-tracking fund is quite simple, it is not without its practical complications which means that in practice index tracking is anything but a passive occupation.

Understanding the index

To begin with, the index-tracking fund manager has to understand exactly:

- How is the index that she is attempting to track constructed:
    - Is it a simple (i.e. unweighted) average of the prices of its component securities, or is it a weighted average (and if so what are the weights – issue size or market value – and how often are they changed?)
    - Is it just a price index or a total return index (i.e. does it also include all the coupon income earned on it)?
- How do the index managers handle:
    - Additions and removals of individual securities to and from the index?
    - Corporate actions on the part of the issuers that have an impact on the securities included in the index? (e.g. issues of additional tranches or partial calls, or any restructuring on an issue)

A detailed discussion of how different bond indices are constructed and maintained lies outside the scope of the IFID Certificate syllabus, but you should of course be aware that technical questions such as these will determine how an index tracker fund has to be constructed, how it needs to be rebalanced over time and how new money received into the fund needs to be allocated.

In the rest of this section we outline two techniques that are commonly used in index tracking – **portfolio sampling** and **synthetic portfolios** – and we also show how the performance of an index tracker is assessed.

7.1. Portfolio Sampling

Buying the whole index

This involves creating a portfolio whose composition mirrors exactly that of the index. In theory, the performance of this portfolio should match the index precisely. In practice this may be difficult to achieve for a number of reasons:

1. **Passive management does not imply a static portfolio**: the fund has to be rebalanced periodically to reflect the changing composition of the index if, for example, a new security is added or if a member of the index makes a new issue.

2. **The fund must be fully invested at all times**: as new money arrives in the fund, as dividends or coupons are paid, or as investors take money out of the fund, the manager is forced to purchase or liquidate stocks in exactly the same proportion as the index. Some of these transactions may involve trading in amounts below normal market size and therefore will attract wider bid-offer spreads.

3. **Market liquidity**: some of the index constituents may be large in terms of market capitalisation but are nevertheless relatively illiquid and expensive to trade.

When we take account the transaction costs involved in tracking a broad index like the S&P 500, the net result is very likely to be underperformance.
The idea of sampling is to construct a portfolio that consists of just a subset of the securities that are represented in the index, but which track the performance of the index reasonably well. In particular, the selected portfolio has to have a **beta** of 1, relative to the index.

Beta: the sensitivity of the return on a security or portfolio to changes in the return on the index to which it belongs

$$\textbf{Beta} = \frac{\textbf{\% change in return on a security}}{\textbf{1\% change in return on index}}$$

Beta is a sensitivity measure that gives you the risk on the selected security or sample portfolio *relative* to the risk on the index as a whole[10].

$\beta = 1$: Sample portfolio's return varies exactly in line with that of the index
$\beta > 1$: Sample portfolio's return is more volatile than that of the index
$\beta < 1$: Sample portfolio's return is less volatile than that of the index

Estimating the sample portfolio's beta

This involves finding the coefficients α and β in the **regression equation** below which best fit the historic returns on the index and those on the sample portfolio:

$$\mathbf{R_i = a_i + b_i \times R_m + e_i}$$

Where:
R_p = The return on the sample fund over a series of sample periods
α_p = An intercept term which reflects a systematic element of fund's return that is unique to it and independent of the index's performance
R_m = The return on the benchmark index over the same series of sample periods
β_p = The slope of the curve, which is the sample fund's beta coefficient
e_p = The **residual error**, that captures the myriad of other factors which affect the sample portfolio's return, other than changes in the broad market index.

The performance of an index fund is assessed by the amount of tracking error that is eventually observed between the fund and the index - i.e. how far does the return on the fund deviate from that on the index.

[10] In the equity markets:

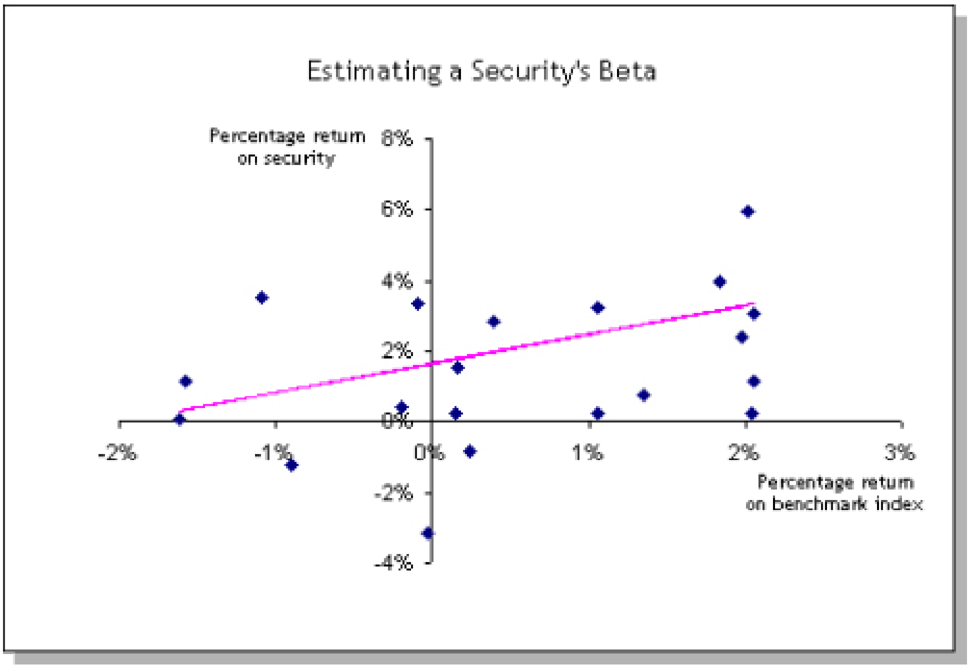
- High-beta stocks are **cyclical** or **aggressive** stocks, such as consumer durables, property and capital equipment manufacturing, which tend to be very sensitive to the overall economic and business cycle

- Low-beta stocks are **non-cyclical** or **defensive** stocks, such as food retailers and public utilities, which normally tend to be less sensitive to changes in broad economic conditions

The aim of sample portfolio index tracking is therefore to find a combination of securities that achieve:

1. A beta of 1
2. An alpha of 0
3. The smallest residual error

The picture below shows a regression line fitted on a small sample of return observations.



Notes:

- Each point on the chart shows the observed return on the index (horizontal axis) against what the return on the sample portfolio would have been, given the return on its component securities over the same period (vertical axis)

- In this case the stock's beta was estimated at 0.83. This means that, on average during the sample period, every 1% change in the return on the index was associated with a 0.83% change in the portfolio's return. Therefore, in a rising market this sample portfolio is likely to underperform the index while in a falling market it will outperform it

- The **coefficient of determination** (or **R^2**) on this regression was only 0.15. This is a measure of the extent to which the observed returns on the portfolio are explained by the return on the index via the beta coefficient – or how close the points on the chart above are to the fitted regression line. On a range of 0-1 (1 being a perfect fit) the fit in this case was not very good. Put another way, the influence of the residual error (unexplained factors) in this sample portfolio is very significant and therefore the likelihood of tracking error using such a portfolio is rather high.

- The portfolio's alpha (also known in the performance assessment literature as the **Jensen index**) was 0.02%. This reflects a tendency of the portfolio to generate marginally positive returns even when the index returns are zero or negative. For an active portfolio manager, any security that has a positive alpha is a Good Thing but an index-tracker should in fact aim to have an alpha of zero, or at least a small alpha relative to its R^2 (known as the **appraisal ratio**).

Portfolio diversification and specific risk

There is a trade-off between the number of securities that are included in the sample portfolio and the amount of tracking error that the portfolio is likely to sustain.

One of the criteria for selecting suitable securities for the sample portfolio might be to include only issues that are large and liquid enough in order to minimise transaction costs. Of course, in this approach to index tracking there will always be a risk of changes in the prices of securities that are in the index but not included in the sample portfolio. This is especially so in the case of credit events, when the price of the affected securities can move very sharply. Moreover, the sample portfolio's beta will rarely stay equal to 1, because security betas tend to change over time.

The larger the number of securities that are included in the sample portfolio, the lower will be its **specific risk** (i.e the standard deviation of the error term in the portfolio's regression formula).

Portfolio risk = Systematic risk + Specific risk

Systematic risk: the risk on a financial instrument that is endemic to the entire market of which it is a part and cannot therefore be eliminated by combining that instrument in a large and well-diversified portfolio of securities from the same market.

Also known as: **Non-diversifiable risk**.

Specific risk: the risk on a financial instrument that is unique to it and may therefore be neutralised by holding that instrument in a large and well-diversified portfolio.

Also known as: **Non-systematic risk**, **Diversifiable risk**.

The figure below shows how the specific risk on a portfolio declines as we increase the number of securities in it[11].

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[11] The ability of portfolio diversification to eliminate specific risk is the foundation of the **Capital Asset Pricing Model** (CAPM), one of the cornerstones of modern portfolio theory. According to CAPM:

- Since diversification provides a relatively easy way of eliminating the specific risk on a security, the only type of risk that should be rewarded with higher yield on a security should be its systematic risk

- Since the beta of a security is a measure of its systematic risk, the excess return on a security over and above the risk-free rate should be proportional to its beta: the higher the security's beta, the higher should be its excess return

This suggests an alternative way of calculating the risk-adjusted return on a security or portfolio, which is used by some fund performance assessment services instead of the Sharpe ratio:

Treynor Ratio = $(R - R_f) / \beta$

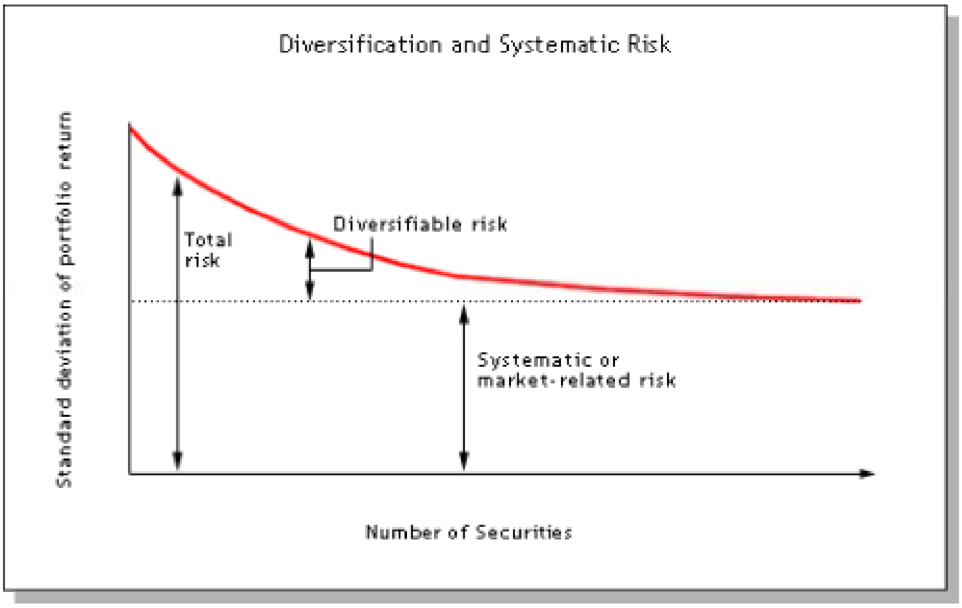
Where:

R = The return on the fund over a series of sample periods

R_f = The risk-free rate

β = The fund's beta coefficient

This information is for your reference only: you are not required to know the details of CAPM or of the Treynor ratio for the IFID Certificate exam.

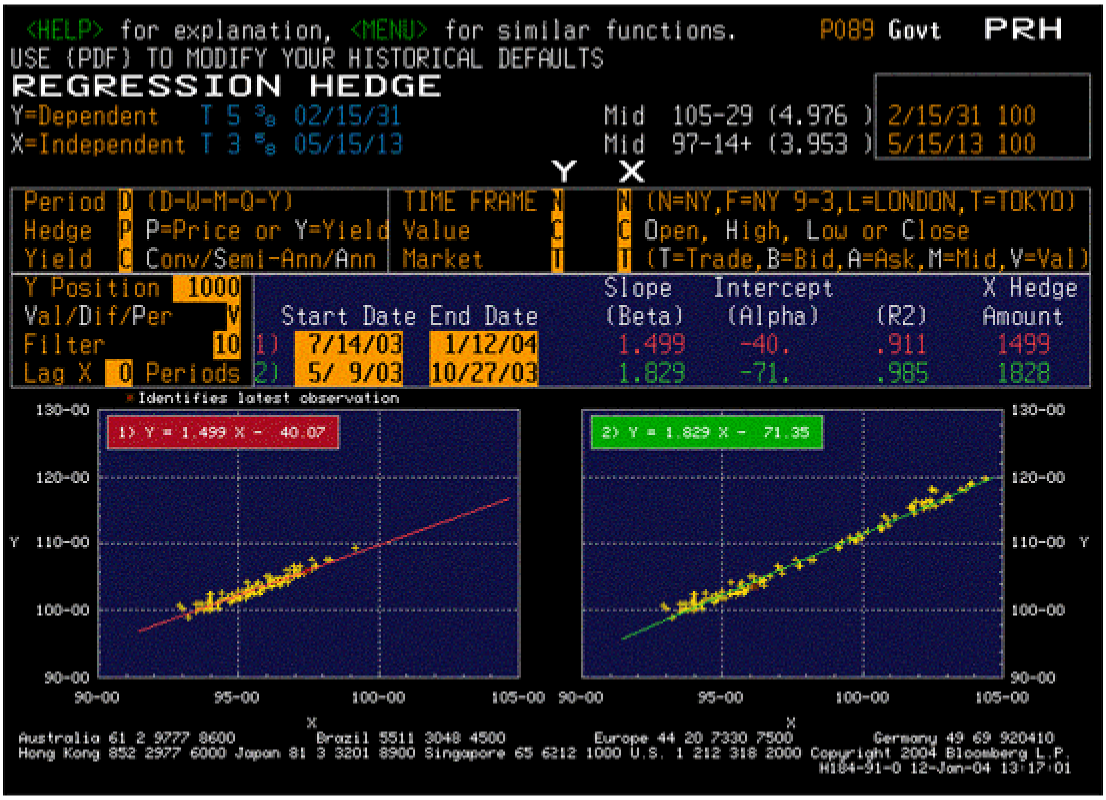


Analytic systems
Example of the Bloomberg regression hedge / tracking function

Below is a sample screen taken from one widely-used provider of market information and analytics.

This example is for illustration purposes only and does not form part of the IFID Certificate syllabus.

Bloomberg regression hedge / tracking analysis



Notes

The single factor model can also be used as a basis for beta-hedging the market risk on a bond (or portfolio), as well as for tracking an index.

The above example shows how much of the 3 5/8% US Treasury of 2013 (bond X) we need in order to track the price performance of the 5 3/8% Treasury of 2031 (bond Y).

For the period July 2003 until January 2004 the function has fitted the following equation (a good fit with an R^2 of 0.911):

Price of Y = -40.07 + 1.499 x Price of X

This means that during the sample period the price of the 2031 has on average changed by 1.499 for every 1.000 change in the price of the 2013. Therefore:

- For every USD 1,000 that we are long in the 2031 bond, we would need to short USD 1,499 of the 2013 in order to obtain a beta-neutral position
- Or alternatively, we could track the price behaviour of a bond index consisting of just USD 1 million of the 2013 with only USD 667,111 of the 2031 (= 1,000,000 / 1.499) and the rest of the client's money can be placed on a short-term money market account

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Single-factor and multi-factor models
The use of single-factor and multi-factor models in active portfolio management.

The sample portfolio return model described in this section is known as a **single factor model** because it essentially tries to explain changes in the return on a security or sample portfolio by changes in just one factor, namely the return on the reference market index.

Such a model could also be used in active portfolio management, where in that context the idea might be to find a portfolio with the highest possible alpha – i.e. one that might outperform the benchmark under all market scenarios.

Indeed, analysts who select portfolios on the basis of their historic performance relative to that of the index which they are trying to beat (so-called **quants analysts**) often use **multi-factor models**, which attempt to explain the return on a security or portfolio on the basis of a number of economic and financial factors, in addition to the reference market index.

Such models have the following generic structure:

$$\mathbf{R} = \alpha + \beta_1 F_1 + \beta_2 F_2 + \beta_3 F_3 + \ldots + \beta_k F_k + e$$

Where:
R = The return on the security or portfolio
α = A component of the return on that security or portfolio that is unique to it and is independent of the returns on other securities or portfolios
F_k = A factor that affects both the return on this security and on the benchmark index
β_k = Sensitivity of the security's return to changes in factor F_k
E = A random residual error

One of the F_k terms in this model is typically the return on the broad market index and its corresponding β_k is therefore the security's beta.

However, the model allows the analyst to identify other so-called **factors of covariance** that may also have significant effects on both the reference benchmark as well as on each security that is a member of it, for example:

- Inflation rate
- Exchange rate
- Economic production and earnings indices for different industry sectors
- Slope of the yield curve, as measured by the spread between the yield on a long term government bond and the yield on treasury bills
- Yield spread between high-yielding and investment grade corporate bonds

As you would expect, different securities will be more or less sensitive to such factors than their index and active portfolio managers who use such models will tilt their portfolios in favour or against such securities, depending on how they see those factors evolving in the future.

7.2. Synthetic Portfolios

An alternative way of index tracking is to simulate the index portfolio using derivatives such as futures or swaps. Rather than buying any securities from the index at all, the client's money is simply placed in a LIBOR-based money market account and this is overlaid with a derivative position that tracks the reference index. Synthetic index trackers have become a major growth area in many countries, as restrictions on the ability of pension funds to use futures and options are gradually being lifted.

Example

Settlement date: 17 December 2003

Situation:
We run a fund valued at USD 500 million that tracks the Lehman Brothers investment grade USD Eurobond index with a duration of 5.63 years and a BPV of 0.05957 per $100 and we intend to track the benchmark index using either one of the following derivatives:

1. Using the 10-year US T-bond futures:
Contract size is USD 100,000 and the CTD is currently the 8.00% maturing in 2013 with a price factor of 1.141076, a duration of 7.18 years and a BPV of 0.087944.

Using the same formula that we developed in module Bond Futures – Hedging:

$$\textbf{Nr of contracts} = \frac{\textbf{Fund size}}{\textbf{Contract size}} \times \textbf{Price factor of CTD} \times \frac{\textbf{BPV of index}}{\textbf{BPV of CTD}}$$

$$= \frac{500{,}000{,}000}{100{,}000} \times 1.141076 \times \frac{0.059570}{0.087944}$$

= 3,864.6 or **3,865 contracts**, rounded.

2. Using an interest rate swap:
The duration of a 7 year swap at the market is 5.48 years and its BPV is 0.053376.

Using a risk-weighted hedging formula like the one developed in module Interest Rate Swaps – Warehousing:

$$\textbf{Notional on swap} = \textbf{Fund size} \times \frac{\textbf{BPV}_{\textbf{Index}}}{\textbf{BPV}_{\textbf{Swap}}}$$

$$= 500{,}000{,}000 \ \frac{0.059570}{0.053376}$$

= **558,022,332**

Practical problems

Like all other index-tracking methods, however, the approach is not without its own problems:

- **Income mismatch**: the total income of the synthetic tracker, being the LIBOR earned on the money market deposit plus the net carry on the derivative position[12], will not be identical to the net income on the index

- **Basis risk on either derivative strategy**:

  - As we explained in Bond Futures – Cheapest to Deliver, the futures price is driven by the CTD and changes in the CTD (or in the net cost of carrying it) can result in changes in the futures price, even if nothing happens in the cash bond market.

    Moreover, the CTD is currently a government bond with 7.18 years duration, while the index that is being tracked is a Eurobond portfolio with 5.63 years duration, so there is some yield curve pivot risk as well as some credit spread risk on this tracking strategy.

  - The swap being used has a slightly different duration than the index, so there is also some yield curve pivot risk in this strategy.

    Moreover, the performance of the index will be partly driven by credit spreads on the Eurobonds that make it up while, as we explained in Interest Rate Swaps – The Swap Spread, there are many factors other than credit risk that drive the spread of swaps over treasuries.

- **Futures variation margin**: any fall in the futures price will result in variation margin calls, forcing the fund manager to liquidate part of the money market portfolio in order to cover them. Conversely, a rise in the futures will earn variation margin, requiring the manager to make additional deposits. Such daily cash flows, which of course do not arise in a securities-based tracker fund, will incur additional transactions costs.

- **Roll risk**: if the tracker is simulated using futures, over time maturing contracts must be replaced with new positions. At each rollover, the maturing contracts that need to be sold off could be trading well below fair value, causing the manager some loss of performance

8. Long Term Funds

So far in this module, we examined different investment techniques used by active and by passive investment funds in order to meet their objectives. In this section, we briefly look at some of the special requirements and constraints faced by another category of institutional investor: the **pension fund** and the **life assurance fund**.

Pension fund: a collective savings vehicle designed to provide its members with a minimum capital sum or income at retirement.

Life assurance fund: savings vehicle designed to provide, in the event of death of the policy-holder, a minimum capital sum or income to named beneficiaries.

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[12]
- In the case of the bond futures overlay, the total income on the fund will be the LIBOR earned on the money market deposit plus the contraction of the gross basis on the futures position, as is converges to zero

- In the case of the swap overlay, the total income will be the swap rate, as the LIBOR leg on the swap more or less matches off the LIBOR earned on the underlying deposit

The very large pension funds of many public sector industries (and also of some private corporations) are registered companies in their own right, with their own staff of investment professionals. Nowadays, however, most company and occupational pension schemes are managed by specialist fund management companies, such as Fidelity Investments, Barclays Global Investors, HSBC Asset Management or General Accident. As well as managing occupational pension funds, such companies also offer personal pension plans to private investors.

Regulatory Status

In most countries the investment regulators grant long term funds privileged tax status:

- Income tax breaks to individuals on fund contributions
- Exemption from income and capital gains tax at least some on the investments

At the same time, however, the regulators impose tight restrictions on the activities of such funds because for most people these are the only sources of post-retirement income – both for themselves as well as for their families. For example, they are typically prohibited from:

- Investing in sub-investment grade bonds
- Taking on positions in unlisted securities
- Short-selling securities
- Creating leveraged positions using borrowing money

Long term funds are typically prevented from engaging in the kinds of strategies that are typical of hedge funds!

Asset and Liability Management

Long term funds are a dominant force in most European countries and are natural buyers of government bonds and investment grade corporate paper. They employ **actuaries** whose job is to:

- Forecast expected future cash payouts from the fund, based on the fund's contractual commitments, the age distribution of its members and mortality tables

- Ensure that the assets in which the fund invests can be reasonably expected to meet those future liabilities

As we saw in module Interest Rate Risk – Using Duration, one of the actuary's job is to monitor the degree of duration matching between the fund's assets and its liabilities.

Moreover, in most cases pension policies and life-assurance payouts are inflation-linked, so the actuary also needs to ensure that their fund's investment portfolio contains sufficient amounts of inflation-linked bonds and/or inflation derivatives to immunise the fund against future changes in inflation rates. We briefly covered the structure of inflation instruments in modules Bond Pricing and Yield – Inflation Bonds and also Interest Rate Swaps – Inflation Swaps.

Unlike active investment funds or hedge funds, the performance of long term fund managers tend to be assessed against the average performance of their peers, rather than against any specified market benchmark index. The 'herd instinct' ensures that most long term funds tend to emulate this average, so individual funds' performances rarely diverge widely.

9. Exercise 1

9.1. Question 1

Compare the two measures of portfolio return studies in this section:

- Money weighted return
- Internal rate of return

a) Which of the following is (or are) a feature of the money-weighted return calculation?

- Has to be estimated by a process of iteration
- The result tends to be reasonably close to the fund's true IRR
- None of these
- Requires the fund to be revalued each time there is a new cash flow going in or out of the fund

9.2. Question 2

Consider the following two assets:

Asset	A	B	Correlations	
Mean return	10%	12%	1.0	+0.5
Standard deviation	7%	8%	+0.5	1.0

a) What is the expected percentage return and standard deviation of a portfolio consisting of 40% of asset A and 60% of asset B? Express both figures in percentages to 1 decimal place. Type your answer in each box below and validate.

Expected return (%)

Standard deviation (%)

b) What would be the effect on the risk of the portfolio if the returns on the stocks were negatively correlated?

- It would be lower
- It would be higher

c) What would be the risk of the portfolio if the stocks were not correlated at all?

- 8%
- 6.7%
- 7.5%
- 5.6%

9.3. Question 3

Assuming you are a rational[13] risk-averse investor, which portfolio out of each of the following pairs would you prefer?

a)

	Return	Risk
Portfolio A	20%	5%
Portfolio B	25%	5%

- Portfolio A
- Portfolio B

b)

	Return	Risk
Portfolio A	17.5%	7%
Portfolio B	17.5%	2%

- Portfolio A
- Portfolio B

c)

	Return	Risk
Portfolio A	10%	6%
Portfolio B	12%	8%

- Depends on your risk/return preferences
- Neither

[13] This just means that for the same risk you prefer more rather than less.

