ISMA CENTRE - THE BUSINESS SCHOOL
OF THE FINANCIAL MARKETS

UNIVERSITY OF READING
ENGLAND

IFID Certificate Programme

Fixed Income Analysis

Money Market Instruments

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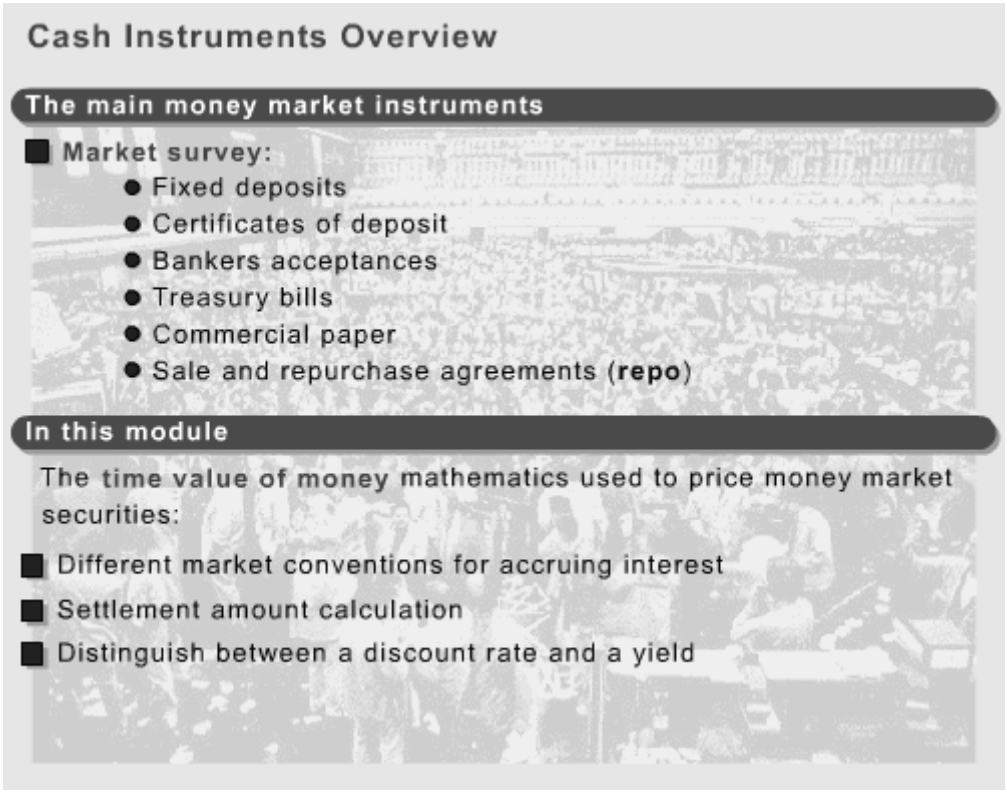
1. Overview



The *Market Survey* introduces the structure and applications of money market securities, including:

- Fixed deposits
- Certificates of deposit
- Bankers acceptances
- Treasury bills
- Commercial paper
- Repo

This module explains the time value of money mathematics used to price these securities.

- We discuss different market conventions for accruing interest
- We distinguish between a discount rate and a yield

The exercises illustrate how these instruments are priced and traded. In the *Trading Session* you will have a chance to develop your market making skills using our Risk Manager Trading Simulation™.

Learning Objectives

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

1. Calculate the settlement amounts due on different money market instruments, given their traded prices
2. Interpret standard market quotations for fixed deposits, certificates of deposit (CDs) and discount securities
3. Distinguish between the discount rate and the money market yield on a discount security
4. Using appropriate day-count conventions, calculate the interest accrued on positions in:
   - Fixed deposits or CDs
   - Discount securities
5. Describe a simple method of converting between money market yields and effective annual yields and explain its limitations

2. Accrued Interest

The money markets include debt instruments with an original maturity of 12 months or less.

Interest in the money markets is typically paid in one single bullet at maturity. This makes the interest payable a **simple interest** calculation. The rate on the loan is normally quoted in percentage per annum, so the interest amount payable is pro-rated by the term of the loan.

Money Market Accruals
(See Bond Pricing - Accrued Interest for accrued interest calculation in the debt capital markets.)

$$\text{Interest amount} = \text{Principal} \times \text{Interest rate} \times \frac{\text{Actual number of days}}{\text{Year basis}}$$

$$\text{Repayment amount (Future value)} = \text{Principal} + \text{Interest amount}$$

$$= \text{Principal} \times \left(1 + \text{Interest rate} \times \frac{\text{Actual number of days}}{\text{Year basis}}\right)$$

Where Year basis = 360 for most currencies except, notably, GBP (**Actual/360**)
365 (or 366 in a leap year) for currencies such as GBP(**Actual/365**)

Example

Accrued interest and total repayment amount calculation.

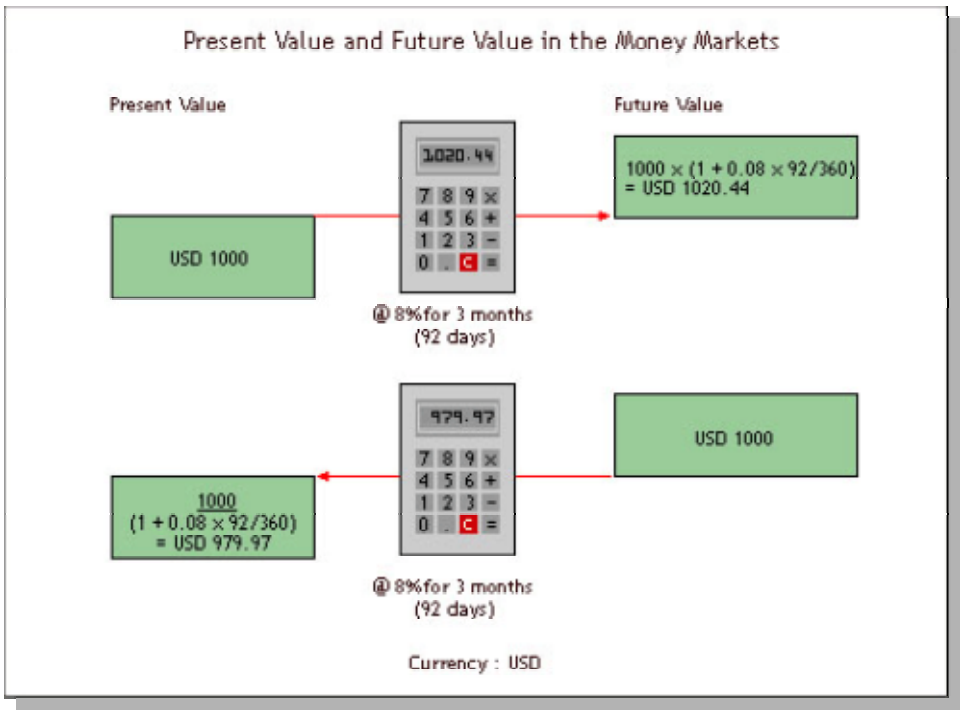
Instrument: Fixed Eurodeposit
Principal: USD 1 million
Value: 17 March
Maturity: 17 July
Rate: 6.55% Actual/360

Repayment amount = Principal + Accrued interest
= 1,000,000 + 1,000,000 x 0.0655 x 122/360
= 1,000,000 x (1 + 0.0655 x 122/360)
= USD **1,022,197.22**

The repayment amount is the **future value** of the instrument. This is equal to the principal deposited on the value date (its **present value**) plus accrued interest.

3. Present & Future Value

In the previous section we showed how to calculate the **future value** of a cash flow invested today at a given rate of interest. The figure below illustrates how the same method may be used to calculate the **present value** of a future cash flow in the money markets.



$979.97 is the present value of $1,000 payable in 3 months: the amount of money which, when invested at 8% for 92 days (actual/360) accumulates to exactly $1,000.

Notice the logic between present and future values:

- When we go forward in time we multiply the present value by a factor (1 + ...)
- When we go back we divide, or **discount**, the future value by the same factor.

Accruing and discounting are fundamental techniques in financial analysis.

3.1. General Formulas

Accruing and Discounting, Money Market Style

$$\text{Future value} = \text{Present value} \times \left(1 + \text{Rate} \times \frac{\text{Actual number of days}}{\text{Year basis}}\right)$$

$$\text{Present Value} = \frac{\text{Future value}}{\left(1 + \text{Rate} \times \frac{\text{Actual number of days}}{\text{Year basis}}\right)}$$

Where Year basis = 360 for most currencies except GBP **(Actual/360)**
365 (or 366 in a leap year) for currencies such as GBP**(Actual/365)**

Note how the discounting of future cash flows in the money market is a lot simpler than in the capital market, as there is no compounding of interest here (see Time Value of Money - Present & Future Value).

4. Pricing CDs

4.1. Pricing CDs Example

Security: Eurodollar certificate of deposit (CD)
Type: actual/360
Issuer: Citibank, London
Amount: USD 1 million
Coupon rate: 5.65% (actual/360)
Issued: 11 December 2001
Maturity: 11 June 2002
Settlement date: 11 March 2002

? What should we pay for this security, if the yield on the instrument is currently 4.75%?

Analysis

Like all fixed income securities, CDs are valued by discounting their future cash flows. Calculating the settlement amount for this trade involves two steps, using formulas we developed earlier in this module:

Step 1: calculate the future value

The coupon rate is fixed when the paper is issued, so its future value is known at the outset. So we first calculate the repayment amount on the CD (i.e. its future value) using the interest accrual formula introduced in section *Present & Future Value:*

Repayment Amount

$$= \text{Principal} \times \left(1 + \text{Coupon Rate} \times \frac{\text{Actual Number of Days}}{\text{Year Basis}}\right)$$

Actual number of days from issue to maturity = 182

Repayment Amount = 1,000,000x(1 + 0.0565 x 182/360)
= USD 1,028,563.89

Step 2: discount the future value

Now there are only 92 days left to the CD's maturity. The settlement amount must be such as to give the investment a yield of 4.75%. So we discount the CD's future value at 4.75% using the present value formula introduced in section *Present & Future Value:*

$$\text{Settlement amount} = \frac{\text{Future value}}{\left(1 + \text{Yield} \times \frac{\text{Actual number of days}}{\text{Year basis}}\right)}$$

$$= \frac{1{,}028{,}563.89}{(1 + 0.0475 \times 92/360)}$$

= USD **1,016,228.01**

The settlement amount is the capital outlay that buys USD 1,028,563.89 payable in 92 days and gives the investor a **yield to maturity** of 4.75%.

4.2. Yield to Maturity

- The return that would be achieved on a debt security if:
  - It was bought for a given settlement value
  - And it is held until maturity
  - And any periodic coupons received are reinvested at the same rate

- The discount rate which makes the present value of the security's future cash flows equal to its settlement value

- The internal rate of return on all the security's cash flows, including the initial outlay

This is the most widely used measure of return in the fixed income markets, and in fact when market participants speak of yield they typically mean yield to maturity. Notice from the settlement calculation above the inverse relationship between settlement amount and yield: the higher the yield on the CD the lower its settlement value.

Fixed Income Markets Law No.1:
The higher the yield on a security the lower is its present value (price varies inversely with yield).

4.3. Market Quotation

CD prices are quoted and traded on a **discount-to-yield** basis: like the underlying deposits, the "price" is a yield to maturity**.**

The following rates show a typical run of rates for top-name (A1/P1 rated) paper:

Prebon International London Prime US Dollar CDs		
1 MONTH	4.50-40	2X5
2 MONTHS	4.65-55	1X3
3 MONTHS	4.85-75	1X5
6 MONTHS	5.05-95	4x3

Explanation

Points to note:

- The terms A1/P1 relate to short term credit ratings assigned by the Standard & Poors and Moody's agencies respectively. They are an on-going assessment of an issuer's credit worthiness as regards to timely payments of all its short term debt obligations.

- 4.85-75 means the market maker bids 3-month paper to give him or her a yield of 4.85% and offers the paper to give the counterparty a yield of 4.75%. The market maker pays less to buy the paper than he wants for selling it. The bid-offer spread in this case is 10 basis points.

- The big figure of 4% is called **the handle** and the small figures (85-75) **the basis**. As in all fast markets brokers often quote just the basis.

- 1X5 means there is USD 1 million available for trading on the bid side and USD 5 million on the offer side.

- Once a price has been hit (e.g. 4.85 or 4.75) the settlement amounts are automatically calculated using the appropriate discounting formula.

4.4. General Formulas

Settlement and Yield on CDs

$$\text{Settlement amount} = \frac{\text{Repayment amount}}{(1 + \text{Yield} \times n / \text{Year basis})}$$

$$= \frac{\textbf{Principal} \times (1 + \textbf{Coupon rate} \times t / \textbf{Year basis})}{(1 + \textbf{Yield} \times n / \textbf{Year basis})}$$

Where:

t = Actual number of days from issue to maturity (the **tenor** or term of the loan)

n = Actual number of days from settlement to maturity (the **residual maturity**)

Year basis = 360 for most currencies except GBP (Actual/360)
365 (or 366 if it is a leap year) for GBP (Actual/365)

$$\text{Yield} = \left[\frac{\text{Principal} \times (1 + \text{Coupon rate} \times t / \text{Year basis})}{\text{Settlement amount}} - 1\right] \times \frac{\text{Year basis}}{n}$$

5. Pricing Discount Paper

5.1. Example

Discount securities such as Treasury bills, BAs and CP are quoted on a discount to par basis.

Unlike CDs, which are quoted on a discount to yield basis, the settlement amount on discount securities is calculated as a percentage discount rate from the face value. This tradition dates back to the way bills of exchange used to be (and still are) discounted by the London merchant banks.

Example

An exporter in London holding a bill of exchange for GBP 100,000 payable in one year wants to raise working capital against it from its bankers. The bank would advance funds to the exporter and take the bill of exchange as collateral. However, if the bank were to advance funds for the full face value of the bill then it would be taking on two types of credit risk:

- A risk on the exporter for the interest payable on the loan. To avoid this risk the bank makes an interest charge up-front by discounting the bill, say, by 10% and remitting the exporter GBP 90,000.
- A risk on the exporter's client for the principal advanced. If the bank held the bill, then at maturity it would be looking to the exporter's client for payment.

This credit risk is mitigated by requiring another bank to accept ultimate liability on the bill, thus transforming the bill of exchange into a **bankers' acceptance**. As such, may be more readily rediscounted (i.e. sold) in the secondary market.

A discount rate is not a rate of interest!

In this example the bank discounting the bill took GBP 10,000 by way of interest. This does not mean that the interest rate charged was 10%: if the exporter were to place the GBP 90,000 on deposit for a year at 10% interest, then at maturity of the deposit he would only recover a total of GBP 99,000 and not GBP 100,000, so the effective rate of interest charged on the bill was more than 10%!

5.2. Settlement

The formula for converting a discount rate into a rate of interest (i.e. a yield) is developed in the next section. Here we shall explain how discount securities are settled and quoted in the market.

Discount Security Settlement

Settlement amount = Face value x (1 - Discount rate x n/Year basis)

Where:
n = Actual number of days to maturity
Year = 360 for most currencies except GBP (Actual/360)
basis 365 (or 366 if it is a leap year) for GBP (Actual/365)

Example

Security: Sterling Treasury Bill
Amount: GBP 500,000
Maturity: 1 October 2002
Settlement date: 12 August 2002

? What should we pay for this bill, if the broker offers it at 7.12%?

The quoted discount rate is on a percentage per annum basis, so the actual discount must be pro-rated down to 50 days in a 365-day year (Actual/365), similar to a rate of interest:

Settlement amount = 500,000 x (1 - 0.0712 x 50/365)
= GBP 495,123.29

5.3. Market Quotation

The following rates show a typical **run** of rates for T-bills:

Martin Brokers London STERLING T-BILLS		
19/8	7.03-00	10X15
26/8	7.05-02	20X5
02/8	7.09-06	25X15
09/9	7.11-08	10X5
16/9	7.13-10	10X15
23/9	7.13-10	15X3
30/9	**7.15-12**	**9X16**

Explanation

Points to note:

- **7.15 - 12** means the market maker discounts paper maturing on 30 September by 7.15% and offers the same paper at a lower discount (higher settlement value) of 7.12%. The market maker pays less to buy the paper than he wants for selling it. The bid-offer spread in this case is 3 basis points.
- The big figure of 7% is called **the handle** and the small figures (15-12) **the basis**. As in all fast markets brokers often quote just the basis.
- **9X16** means there are GBP 9 million available for trading on the bid side and GBP 16 million on the offer side
- Once a price has been hit (e.g. 7.15 or 7.12) the settlement amount may be calculated using the appropriate discounting formula.

6. Yield Conversions

6.1. Discount Rate Concept

As we saw in *Pricing Discount Paper*, a discount rate is not the same as a yield to maturity.

Example

A bank discounts a 1 year bill of exchange for a client, with a face value of GBP 100,000 at 10%. The bank therefore pays the client GBP 90,000 for the bill.

? What is the return on the investment for the bank?

Return = 100,000 - 90,000
= GBP 10,000

Expressed as a percentage of capital outlay:

$$\text{Return} = \frac{(100{,}000 - 90{,}000)}{90{,}000} \times 100$$

= **11.11**%

! The yield on discount paper is always higher than the discount rate!

By calculating an effective yield for the transaction the bank can compare the return on this paper with the return on comparable money market instruments.

6.2. Discount Rate to Money Market Yield

$$\text{Money market yield} = \left(\frac{\text{Maturity amount - Settlement amount}}{\text{Settlement amount}}\right) \times \frac{\text{Year basis}}{t} \times 100$$

Where:
t = Actual number of days to maturity
Year basis = 360 for most Eurocurrencies except GBP (Actual/360)
365 (or 366 if it is a leap year) for GBP (Actual/365)

Settlement amount = Face value x (1 - Discount rate x t / Year basis)

Substituting for Settlement amount in the Yield equation above, we can obtain:

Discount Rate to Money Market Yield (IFID exam formula):

$$\textbf{Money market yield} = \frac{\textbf{Discount rate x Year basis}}{\textbf{[Year basis - (Discount rate x t)]}}$$

Money Market Yield to Discount Rate (IFID exam formula):

$$\textbf{Discount rate} = \frac{\textbf{Money market yield x Year basis}}{\textbf{[Year basis + (Money market yield x t)]}}$$

Example: discount rate to yield

Security: Sterling Treasury Bill
Amount: GBP 500,000
Maturity: 1 October 2002
Settlement date: 12 August 2002

? What is the yield on this bill if it was bought at a discount rate of 7.12%?

$$\text{Yield to maturity} = \frac{0.0712 \times 365}{(365 - 0.0712 \times 50)}$$

$$= 0.0719 \text{ or } \mathbf{7.19\%}$$

6.3. Bond Equivalent Yield Concept

Different money market day-count conventions imply that the yield you would see quoted on a broker screen may not be the same as the **true yield** that you get.

Example

Instrument 1:	Eurodollar CD
Type:	Actual/360
Principal:	USD 1 million
Maturity:	18 March 2003
Coupon rate:	10%
Settlement date:	18 March 2002
Issue date:	18 March 2002
Settlement amount:	USD 1 million

Instrument 2:	10% USD Eurobond maturing 18 March 2003
Type:	Annual, 30/360
Principal:	USD 1 million
Settlement date:	18 March 2002
Price:	100.00

? If the two instruments have the same maturity, coupon and credit risk, which one would you prefer?

Both securities cost the same, but at maturity the CD repays the principal plus:

$$\text{Interest amount} = 1{,}000{,}000 \times 0.10 \times 365/360$$
$$= \text{USD } 101{,}388.89$$

The bond pays a coupon of only USD 100,000 (10% of 1,000,000). The CD rate (actual/360) therefore understates its true yield (or **bond equivalent yield)**.

$$\text{Bond equivalent yield} = \frac{101{,}388.89}{1{,}000{,}000} \times 100 = 10 \times \frac{365}{360}$$

$$= \mathbf{10.139\%.}$$

6.4. Money Market to Bond Equivalent Yield

Money Market Yield and Bond Equivalent Yield Conversions
(IFID exam formula)

Annual return on money market = Annual return on bond

$$(1 + MMY \times 365/360) = (1 + BEY)$$
$$MMY \times 365/360 = BEY$$

Where:
MMY = Money market yield
BEY = Bond equivalent yield

Money market yield		**Bond equivalent yield**	**Conversion method**
		30/360	
Actual/360	--------->	Actual/Actual	**BEY = MMY x 365/360**
		Actual/365	
		30/360	
Actual/360	<---------	Actual/Actual	**MMY = BEY x 360/365**
		Actual/365	
		30/360	
Actual/365	<------->	Actual/Actual	**None**
		Actual/365	

Significance of Yield Conversions

Knowing how to convert between money market rates and true yields is important because:

- In some markets, notably UK and Germany, yields on bonds which are in their final coupon period are quoted on a money market basis, rather than on a bond basis
- Where this is not the case, yield on bonds in their final coupon period must be converted to money market equivalents to make them comparable with money market securities - e.g. government bonds vs. Treasury bills
- Bond positions are typically funded through money market instruments such as repo or fixed deposits. A trader calculating the carry on a position must factor the cost of funding from the yield on the security.

The yield conversions presented here convert from money market yield to effective bond yield and vice versa.

See Bond Pricing and Yield - Yield Conversions for an explanation of how to convert between annual and semi-annual bond yields.

7. Exercises

7.1. Question 1

Question 1

Security:	SD Fixed Rate CD
Type:	Actual/360
Issuer:	JP Morgan Chase, London
Amount:	USD 100,000.00
Rate:	5.3/4%
Issued:	5 July 2002
Maturity:	7 July 2003
Settlement:	11 February 2003
Price:	5.38%

a) What is the repayment amount on this CD at maturity?

USD

b) Effectively, the CD pays more than 5.75% interest because:

- The actual number of days is 367 but the basis is 360
- The borrower pays a yield spread over the coupon rate
- Interest is paid semi-annually, so it compounds
- The actual number of days is 360 but the basis is 365

c) What is the bond equivalent yield on this investment, annually compounded, to the nearest 2 decimal places?

d) What is the settlement amount on this trade?

USD

e) You bought this CD at 5.38% for settlement 11 February 2003 and you re-sell it at 5.50% for settlement 21 February. What is the gross profit or loss on the trade:

(i) In USD?

(ii) As a percentage of capital employed (annualised, actual/360, to 2 decimal places) - i.e. the horizon return?

Return

f) We earned less than the yield on the CD because:

- Interest is paid net of withholding tax
- Market yield rose, so we made a capital loss
- Yields rose so we accrued less interest
- Funding costs were high

7.2. Question 2

Question 2

Security:	USD Bankers Acceptance
Type:	Actual/360
Acceptor:	HSBC, New York
Amount:	USD 100,000.00
Underlying transaction:	Coal exports
Maturity:	3 July 2002
Settlement:	7 February 2002
Price:	5.27%

a) What is the settlement amount on the trade, in USD?

b) What is the money market yield on this investment, to the nearest 2 decimal places?

7.3. Question 3

Question 3

A 91-day US T-bill is quoted at 8.60%.

a) What is its annually compounded bond-equivalent yield, rounded to 2 decimal places?