CHANGES TO THE SYLLABUS AND CORE READING FOR SUBJECT ST6 FOR THE 2018 EXAMINATIONS

Changes to the Syllabus and their impact on Core Reading

There have been no changes to the Syllabus.

Changes to Core Reading

UNIT 5

Amendments have been made to section 8 of this Unit and a revised Unit is attached.

The only other changes that have been made to the Core Reading are to correct typographical errors and improve the style.

Attachment: Unit 5

UNIT 5 — INTEREST RATE DERIVATIVES

Syllabus objectives

(e) Define and describe the following interest rates, and interest rate derivatives:

- Treasury rates
- LIBOR rates
- Repo rates
- Zero rates
- Forward rates
- Forward rate agreements
- Interest rate futures
- Treasury bond futures
- Interest rate swaps
- European swap options (swaptions)
- Caps and caplets
- Floors and floorlets
- Bermudan swaptions

1 Treasury rates

The *Treasury rate* is the rate of interest applicable to borrowing by a government in its own currency. Treasury rates are regarded as risk-free rates. However, derivatives traders tend to use LIBOR rates as risk-free rates.

2 LIBOR rates

2.1 Definition

LIBOR stands for *London Interbank Offered Rate*. It was developed in the 1980s and is the rate which large banks active in a particular money market charge each other for borrowing (hence the word "offer") in a currency for a particular term. LIBOR is administered by Intercontinental Exchange (ICE), which sets the rules and runs the process by which it is calculated.

LIBOR rates apply to the short-term international interbank market for large loans with maturities from 1 day (overnight) to 12 months. LIBOR is the most common reference base for pricing interest rate sensitive instruments, e.g. swaps, and loans to larger companies and institutions.

LIBOR is a reference rate which is officially fixed in London once a day by a defined group of large banks, while the rate that each bank could borrow at will differ somewhat and change throughout the day.

It is not restricted to Sterling – there are currently LIBOR rates for five major international currencies:

Currency	**Symbol**
Pound Sterling	GBP
US Dollar	USD
Euro	EUR
Japanese Yen	JPY
Swiss Franc	CHF

Central banks (such as the Bank of England, the US Federal Reserve and the European Central Bank) fix official base rates monthly, but LIBOR reflects the actual rate at which banks borrow money from each other. It is accepted as an accurate barometer of how global markets are reacting to market conditions and is referenced in market standard ISDA documentation, supporting a swap market estimated at $350 trillion and a loan market estimated at $10 trillion.

However, as described below, the severe liquidity shortage in the interbank market during the 2007/08 "credit crunch" led some to question LIBOR's effectiveness as a benchmark for interest rates, and the accuracy of the measure has also been challenged.

2.2 Setting process and calculation

A panel of between eight and eighteen banks is appointed to set the LIBOR rate for each currency. The aim is to produce a reference panel of banks which reflects the balance of the market, by country and by type of institution. Individual banks are selected within this guiding principle on the basis of reputation, credit standing, scale of market activity and perceived expertise in the currency concerned. The composition of the panels is reviewed annually by ICE.

ICE uses Reuters to fix and publish the data daily, usually before 12 noon UK time. It assembles the interbank borrowing rates from the contributor panel banks at 11am, looks at the middle two quartiles of these rates (discarding the top and bottom quartile) and uses this to calculate an average, which then becomes that day's LIBOR rate. This process is followed repeatedly to create rates for all seven maturities (ranging from overnight to 12 months) and all five currencies for which a LIBOR rate is quoted. The quotes from all panel banks are published on-screen to ensure transparency.

LIBOR is not a compounded rate, but is calculated on the basis of actual days in funding period divided by 360. The formula for calculating interest using LIBOR is:
interest due = principal × (LIBOR rate/100) × (actual no. of days in interest period/360)

For Sterling only, the calculation basis is 365 days, not 360 days. It is also important to work out the exact actual number of days in the funding period: there are not always 90 days in a 3 month period: there could be 89 or 91, depending on the precise calendar months involved.

Rates for periods for which LIBOR is not set are obtained by linear interpolation – for example, to arrive at a 75-day LIBOR rate, interpolate between the 2 month and 3 month rates.

2.3 Spread to government yields

LIBOR rates are dependent on a number of factors such as: local interest rates, banks' expectations of future rate movements, the profile of contributor banks, and liquidity in London in the currency concerned.

LIBOR rates are different from government bond yields because bank counterparties are not credit risk free (in the way that government debt is, at least in its own country). The spread between government and LIBOR rates is usually positive (LIBOR is higher), but occasionally supply and demand effects will distort this relationship. This does not prevent the LIBOR rate from being the standard rate for swaps since the interbank market is the place where most swaps are transacted.

2.4 LIBOR during the "credit crunch"

During the "credit crunch" of 2007/8, the interbank market became very illiquid, as banks were unable to obtain the usual amount of long-term funding, so were unable to lend to each other except at the very shortest time period (overnight). There were two important impacts from this crisis.

Firstly, on several days during 2007 and 2008 it was not possible to obtain interbank quotes with the usual reliability, either because a two-way quote was not being made or the amounts being traded were too small. This led to some discontinuities in the LIBOR time series. Secondly, a large liquidity premium developed in the interbank market. The spread between LIBOR and the official intervention rate in a number of currencies rose to unprecedented levels – from a norm of around 25bps (0.25%) to a peak (albeit briefly) of over 4% at the time of the collapse of Lehman Brothers in September 2008. The spread, known as the "LIBOR-OIS spread" (OIS = Overnight Index Swap), remained well above 1% for many months during 2008 and into 2009.

The period was a difficult one for LIBOR, but the then administrator (the British Bankers' Association, BBA) was able to ensure that the rate setting process continued through the crisis. Questions were asked, though, about the suitability of LIBOR as the benchmark for rate-setting on a number of loans and financial instruments. An investigation was undertaken by the BBA to ascertain how the construction and operation of LIBOR could be strengthened for the future. The resulting report proposed a number of actions: tighter scrutiny of the contribution mechanism, wider panel membership, re-assessment of the need for transparency where it could result in adverse market reaction, and some details regarding timing of quotes and normal market size.

The BBA concluded that, in the particularly benign conditions for credit markets over the previous decade, insufficient attention may have been paid by certain parties in the interbank markets to funding liquidity risk and counterparty risk, and that these aspects would need to be addressed. (Funding liquidity risk is the risk that a lender may be unable to raise funds as expected as liabilities fall due; counterparty risk is the risk that the party who borrowed the money may not be able to repay as agreed.) Despite the distortions that occurred during the crisis, the status of LIBOR rates as benchmarks has been accepted by the markets, ultimately because it would not be feasible in the short run to replace them with any other sets of rates that are as credible.

2.5 LIBOR "scandal"

In 2012, it was discovered that some banks were fraudulently mis-reporting the interest rates which they were submitting (and colluding with other banks in doing so) in order to manipulate LIBOR.

This led to increased validation requirements (e.g. provision of records of actual inter-bank transactions) and a change in the regulatory oversight of LIBOR in the UK.

3 Repo rates

A repo (or repurchase) agreement is the sale of securities to a counterparty plus an agreement for the seller to buy back the securities from that counterparty at a later date. This date may be fixed for a term repo agreement or unspecified in an open repo agreement.

Repo agreements tend to be money market instruments (i.e. they are typically short term transactions from overnight to a few days). Longer term repo agreements may have a maturity of up to two years or, as noted above, may even be open-ended.

The difference between the price at which the securities are sold and the price at which they are repurchased under a repo agreement is the interest earned by the counterparty. The interest rate is referred to as the *repo rate*. The repo rate is typically only slightly higher than the corresponding Treasury rate.

The seller has effectively used their securities as collateral for a loan at a fixed rate of interest. Typically highly liquid securities are preferred for repo agreements, so that they can readily be sold if the seller defaults and so that the buyer (who is in the "reverse repo" position, i.e. has an agreement to sell the securities back) can obtain them readily on the open market if they have created a short position.

Tri-party repo arrangements exist, whereby a third party agent (a custodian bank) administers the agreement in terms of settlement and collateral management. The third party agent does not participate in the risk of the transaction (e.g. default by the other party).

4 Zero rates

The n-year *zero rate* is the rate of interest earned on an investment that starts today and lasts for n years, where all the interest and principal is realised at the end of n years. The n-year zero rate is sometimes also referred to as the n-year *spot rate*.

5 Forward rates

A *forward interest rate* is the interest rate implied by current zero rates for a specified future time period. If R_1 and R_2 are the zero-coupon rates for maturities T_1 and T_2 respectively, and R_F is the forward interest rate for the period between T_1 and T_2, then

$$R_F = \frac{R_2T_2 - R_1T_1}{T_2 - T_1}$$

6 Forward rate agreements

A forward-rate agreement (FRA) is a forward contract where the parties agree that a certain interest rate will apply to a certain principal amount during a specified future time period. The value, V, of a FRA where it is specified that an interest rate R_K will be earned for the period of time between T_1 and T_2 on a specified principal of L can be evaluated as:

$$V = L(R_K - R_F)\,(T_2 - T_1)\ e^{-R_2T_2}$$

i.e. the present value of the difference between the interest payments.

7 Interest rate futures

Interest rate futures contracts come in two main types: those where the underlying is a government bond (Treasury bond futures – see below) and those where the underlying is a short-term Eurodollar or LIBOR interest rate.

Three-month interest rate futures contracts are typically available in a wide range of currencies. The contracts trade with delivery months of March, June, September and December up to ten years into the future (as well as short-maturity contracts with other delivery months). The variable underlying the contract is the relevant market interest rate applicable to a 90-day period beginning on the third Wednesday of the delivery month.

If Q is the quoted price for a futures contract, the contract price is

$$10{,}000\,[100 - 0.25(100 - Q)]$$

A change of one basis point, 0.01, in a Eurodollar futures quote corresponds to a contract price change of \$25.

When the third Wednesday of the delivery month is reached and the actual interest rate for the 90-day period is known, the contract is settled in cash.

If Q is a Eurodollar futures quote, $(100 - Q)\%$ is the Eurodollar *futures interest rate* for a three-month period beginning on the third Wednesday of the delivery month.

8 Treasury bond futures

Under a Treasury (or government) bond futures contract, settlement is made when the party with the short position delivers a government bond in return for cash paid by the party with the long position. Treasury bond futures are available for many government bond issuers including the United States, United Kingdom and Japan.

Different Treasury bond futures contracts are available for different underlying tenors (i.e. terms to maturity) of bonds. For shorter tenors, i.e. up to 10 years, the contracts may be termed Treasury note futures.

For example, US Treasury bond/note futures are available for bond tenors of 2 years, 5 years, 10 years and 30 years. Under the 10-year US Treasury note futures contract, any government bond with a remaining maturity between 6.5 and 10 years can be delivered. Similarly, under the 5-year US Treasury note futures contract, the bond delivered must have a remaining maturity of between 4 years 2 months and 5 years 3 months.

When any particular bond is delivered, a parameter known as a *conversion factor* defines the price received by the party with the short position, who can choose which of the available bonds is "cheapest-to-deliver" i.e. the bond for which [quoted price − (quoted futures price × conversion factor)] is least.

If we assume that both the cheapest-to-deliver bond and the delivery date are known, the government bond futures contract is a futures contract on a security providing the holder with a known income. Today's futures price F_0 is therefore related to today's spot bond price B_0 by

$$F_0 = (B_0 - I)\, e^{rT}$$

where F_0 is the cash futures price, B_0 is the cash bond price, I is the present value of the coupons during the life of the futures contract, T is the time when the futures contract matures and r is the risk-free interest rate applicable to an investment maturing at time T.

9 Interest rate swaps

In a “plain vanilla” interest rate swap, company B (the “payer”) agrees to pay company A (the “receiver”) cash flows equal to interest at a predetermined fixed rate on a notional principal for a number of years. At the same time, company A agrees to pay company B cash flows equal to interest at a floating rate on the same notional principal for the same period of time. The currencies of the two sets of cash flows are the same.

A swap position under which the fixed rate is received may be referred to as a “receiver swap”, with the opposite position being termed a “payer swap”. In the example above, company A has entered into a receiver swap and company B a payer swap.

Note that the notional principal is used only for the calculation of interest payments. The principal itself is not exchanged.

The swap contract has the effect of transforming the nature of the liabilities. In the example above, company B can use the swap to transform a floating-rate loan into a fixed-rate loan, while, for company A, the swap has the effect of transforming a fixed-rate loan into a floating-rate loan. Equally, swaps can be used to transform the nature of an asset from one earning a fixed rate of interest into one earning a floating rate of interest (or vice versa).

Usually, two non-financial companies do not get in touch directly to arrange a swap. They each deal with a financial intermediary (such as a bank) which is remunerated by the difference between the values of a pair of offsetting transactions, *providing neither client defaults on their swap*. The intermediary has two separate contracts, one with company A and the other with company B. (In most instances, company A will not even know that the intermediary has entered into an offsetting swap with company B, and vice versa.) If one of the companies defaults, the intermediary still has to honour its agreement with the other company. The spread earned by the intermediary is partly to compensate it for the default risk it is bearing. (In practice, any outstanding risk to the intermediary is normally collateralised with securities, minimising the default risk.)

In practice, it is unlikely that two companies will contact an intermediary at the same time and want to take opposite positions in exactly the same swap. For this reason, a large financial institution will be prepared to enter into a swap without having an offsetting swap with another counterparty in place. This is known as *warehousing* swaps.

If we assume no possibility of default (which is reasonable when collateralised), an interest rate swap can be valued as a long position in one bond compared to a short position in another bond, since the notional principal is the same in both cases.

10 European swap options

Swap options (or *swaptions*) are options on interest rate swaps. They give the holder the right, but not the obligation, to enter into a certain interest rate swap at a certain time in the future.

Swaptions provide companies with a guarantee that the fixed rate of interest they will pay on a loan at some future time will not exceed some level. The company is able to benefit from favourable interest rate movements while acquiring protection from unfavourable interest rate movements.

11 Caps and caplets

11.1 Caps

First let us consider a floating-rate note where the interest rate is reset periodically equal to LIBOR. The time between resets is known as the *tenor*. Suppose the tenor is 3 months. The interest rate on the note for the first 3 months is the initial 3-month LIBOR rate; the interest rate for the next 3 months is set equal to the 3-month LIBOR rate prevailing in the market at the 3-month point; and so on.

An interest rate cap is designed to provide insurance against the rate of interest on the floating-rate note rising above a certain level, known as the *cap rate*. The cap provides a payoff equal to the excess of the interest on the floating rate over the interest determined at the cap rate. The payoff would not occur on the reset date but would occur, in the example above, three months afterwards to reflect the time lag between an interest rate being observed and the corresponding payment being required. If LIBOR were less than the cap, there would be no payoff. Caps are usually defined so that the initial LIBOR rate, even if it is greater than the cap rate, does not lead to a payoff on the first reset date.

11.2 Caplets

A cap can be expressed as a portfolio of interest rate options as follows:

Consider a cap with a total life of T, a principal of L, and a cap rate of R_K. Suppose the reset dates are $t_1, t_2, \ldots, t_n$ and define $t_{n+1} = T$. Define R_k as the interest rate for the period between time t_k and t_{k+1} observed at time t_k ($1 \le k \le n$). The cap leads to a payoff at time t_{k+1} ($k = 1, 2, \ldots, n$) of

$$L\delta_k \max(R_k - R_K, 0)$$

where $\delta_k = t_{k+1} - t_k$. Both R_k and R_K are expressed with a compounding frequency equal to the frequency of the resets.

The equation above is a call option on the LIBOR rate observed at time t_k with the payoff occurring at time t_{k+1}. The cap can therefore be expressed as a portfolio of n such options. These n options are known as *caplets*.

12 Floors and floorlets

12.1 Floors

A floor is similar to a cap, but it provides a payoff when the interest rate on the underlying floating-rate note falls below a certain rate instead of above. Using the notation in Section 11.2 above, the payoff at time t_{k+1} becomes:

$$L\delta_k \max(R_K - R_k, 0)$$

12.2 Floorlets

Using the analogy in Section 11.2 above, a floor can be similarly expressed as a portfolio of options, this time a portfolio of put options on interest rates. Each of the individual options is known as a *floorlet*.

13 Bermudan swaptions

Bermudan swaptions are similar to European swaptions but can be exercised on some or all of the payment dates of the underlying swap.

Bermudan swaptions are difficult to value. Most traders value them using the one-factor no-arbitrage models discussed in Unit 14. A more accurate method is the least-squares approach adopted by Longstaff and Schwartz, as described in Unit 11.

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