$$f(x+\Delta x) = f(x) + \frac{\partial f}{\partial x}\Delta x + \frac{1}{2}\frac{\partial^2 f}{\partial x^2}(\Delta x)^2 + \dots$$

$$B(y+\Delta y) = B(y) + \frac{\partial B}{\partial y}\Delta y + \frac{1}{2}\frac{\partial^2 B}{\partial y^2}(\Delta y)^2 + \dots$$

duration

convexity

$$\frac{B(y+\Delta y) - B(y)}{B(y)} = \frac{1}{B}\frac{\partial B}{\partial y}\Delta y + \frac{1}{B}\frac{1}{2}\frac{\partial^2 B}{\partial y^2}(\Delta y)^2 + \dots$$

Bond Duration

Duration and **convexity** are two of the most important parameters to estimate when investing in a bond, other than its yield.

$\Rightarrow$ Bond price is a decreasing and convex function of the bond yield.

The most frequently used bond duration measure in practice is **modified duration**.

The **modified duration** of a bond is the rate of change of the price of the bond with respect to the yield of the bond, normalized by the price of the bond, and with opposite sign, i.e.

$$D = -\frac{1}{B}\frac{\partial B}{\partial y}.$$

The price B of the bond is considered a function of the yield y and with cash flows c_i at time t_i.

Modified duration measures the rate of return of the bond price for small changes in the bond yield

Bond Duration

$D = -\frac{1}{B} \cdot \frac{\partial B}{\partial y}$

Under continuous compounding, we have

$$B = \sum_{i=1}^{n} c_i e^{-yt_i} \qquad \Rightarrow \qquad \frac{\partial B}{\partial y} = -\sum_{i=1}^{n} t_i c_i e^{-yt_i},$$

and it follows that the modified duration D of the bond is

$$D = \frac{1}{B} \sum_{i=1}^{n} t_i c_i e^{-yt_i}.$$

From here we see that this is just a "time weighted" average of the of the cashflows' NPV.

Example Suppose the bond yield is 4% and continuously compounded, what is the modified duration of a zero coupon bond paying maturing at the end of the 2^{nd} year. Ans.: 2

Example A $2y$ coupon bond is trading at 102. The continuously compounded yield is 5.2756%, and the coupon is 6.5 paid annually. Calculate the modified duration of this bond. Ans.: 1.9396

①

$$D = \frac{1}{\cancel{100e^{-4\%\cdot 2}}} \times \left[2 \times \cancel{100 \times e^{-4\%\cdot 2}} \right]$$

$$= 2$$

②

$$D = \frac{1}{102} \times \left[1 \times 6.5 \times e^{-5.2756\%\cdot 1} \right.$$

$$\left. + 2 \times 106.5 \times e^{-5.2756\% \times 2} \right]$$

$$=$$

Frederik Macaulay 1930s

Bond Duration

The **Macaulay Duration** of a bond is defined as the weighted averaged of the cash flow times, with weights equal to the value of the corresponding cash flow discounted with respect to the yield of the bond, i.e.

$$D_{\mathsf{Mac}} = \frac{1}{B}\sum_{i=1}^{n} t_i c_i \mathsf{Discount}(t_i, y),$$

where $\mathsf{Discount}(t_i, y)$ is the discount factor corresponding to time t_i, computed with respect to the yield of the bond.

Based on the definition, we see that if the bond yield is continuously compounded, then the Macaulay duration is exactly equal to the modified duration.

If the bond yield is discretely compounded (as is the case in practice), the modified duration is:

$$D = \frac{D_{\mathsf{Mac}}}{1 + \frac{y}{m}}.$$

$$B(y) = \sum_{i=1}^{n} c_i \cdot \frac{1}{\left(1+\frac{y}{m}\right)^{m \times t_i}}$$

$$= \sum_{i=1}^{n} c_i \cdot \left(1+\frac{y}{m}\right)^{-m \times t_i}$$

$$\frac{\partial B}{\partial y} = -\sum_{i=1}^{n} \cancel{m}\, t_i \cdot c_i \left(1+\frac{y}{m}\right)^{-m \times t_i - 1} \times \frac{1}{\cancel{m}}$$

$$= -\sum_{i=1}^{n} \frac{t_i\, c_i}{\left(1+\frac{y}{m}\right)^{m \times t_i}} \cdot \frac{1}{1+\frac{y}{m}}$$

$$-\frac{1}{B}\frac{\partial B}{\partial y} = \frac{1}{B} \cdot \sum_{i=1}^{n} \frac{t_i\, c_i}{\left(1+\frac{y}{m}\right)^{m x t_i}} \cdot \frac{1}{1+\frac{y}{m}}$$

Bond Duration

- Macaulay duration estimates the point in time when the future value of the bond would remain unchanged for small parallel changes in the zero rate curve.
- Macaulay duration is defined as the "time weighted" average of the cashflows NPV.
- For continuous compounding, the discount factors are $\text{Discount}(t_i, y) = e^{-yt_i}$, and it follows that $D_{Mac} = D$.
  - $\Rightarrow$ In other words, the Macaulay duration and the modified duration of a bond have the same value if interest is compounded continuously.
  - $\Rightarrow$ This is not the case if interest is compounded discretely, when the modified duration of a bond is smaller than its Macaulay duration.

Using Modified Duration

$D = -\frac{1}{B} \cdot \frac{\partial B}{\partial y}$

Let Δy be the change in the yield of the bond, and let

$$\Delta B = B(y + \Delta y) - B(y)$$

be the corresponding change in the price of the bond. The discretized version of the modified duration formula becomes

$$D \approx -\frac{1}{B} \cdot \frac{B(y + \Delta y) - B(y)}{\Delta y} = -\frac{\Delta B}{B \cdot \Delta y}$$

$$\Rightarrow \quad \frac{\Delta B}{B} \approx -D\Delta y$$

In other words, the return $\frac{\Delta B}{B}$ of the bond can be approximated by the duration of the bond multiplied by the parallel shift in the yield curve, with opposite sign.

For very small changes in the yield of the bond, this approximation formula is accurate. For larger changes, convexity is used to better capture the effect of changes in the bond yield.

Bond Convexity

The **Convexity** C of a bond with price B and yield y is defined as

$$C = \frac{1}{B}\frac{\partial^2 B}{\partial y^2}.$$

Under continuous compounding, we can see that

$$C = \frac{1}{B}\sum_{i=1}^{n} t_i^2 c_i e^{-y t_i}.$$

Let D and C be the modified duration and the convexity of a bond with yield y and value $B = B(y)$. Then

$$\frac{\Delta B}{B} \approx -D\Delta y + \frac{1}{2}C \cdot (\Delta y)^2,$$

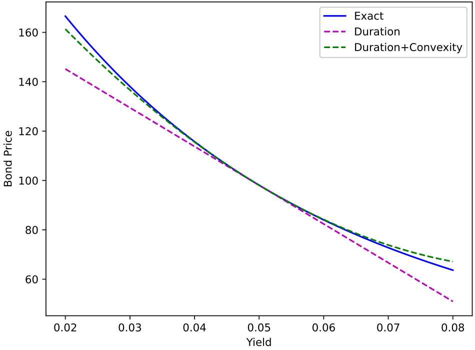
where $\Delta B = B(y + \Delta y) - B(y)$.

Bond Convexity

We can use modified duration and convexity to estimate the changes in bond price due to parallel yield movements:

$$1^{st}\text{-order:} \quad B(y+\Delta y) \approx B(y) - D\Delta y B(y)$$

$$2^{nd}\text{-order:} \quad B(y+\Delta y) \approx B(y) - D\Delta y B(y) + \frac{1}{2}C\cdot(\Delta y)^2 B(y). \quad \triangleleft$$



Bond Convexity

Note that regardless of whether the yield goes up or down, a bond with higher convexity provides a better return when the bond yield moves.

Note also that an approximate value for the percentage return $\frac{\Delta B}{B}$ of a long bond position can be computed using this formula without requiring specific knowledge of the cash flows of the bond.

A practical note about bond trading—for two bonds with the same duration, the bond with higher convexity provides a higher return for small changes in the yield curve.

$\Rightarrow$ Regardless of whether the yield goes up or down, bond with higher convexity provides a higher return, and is the better investment, all other things being considered equal.

Bond Convexity

① $C = \frac{1}{102} \times \left[1^2 \cdot 6.5 \cdot e^{-y \cdot 1} + 2^2 \cdot 106.5 \cdot e^{-y \cdot 2} \right]$

Example A $2y$ coupon bond is trading at 102. The continuously compounded yield is 5.2756%, and the coupon is 6.5 paid annually.

1. Calculate the convexity of this bond. ans.: 3.8187
2. Suppose the yield goes up by 2 basis points, calculate the return $\frac{\Delta B}{B}$ of this bond. ans.: -0.037%
3. Compare the bond return to the approximation we obtain using modified duration and convexity. ans.: -0.038%

② $B(5.2756\%) = 102$

$B(5.2956\%) = \underline{B'}$

$\frac{B' - 102}{102} = \underline{\quad}$

③ $\frac{\Delta B}{B} \simeq -D \cdot \Delta y + \frac{1}{2} C \cdot (\Delta y)^2$

Dollar Duration

$$D = -\frac{1}{B} \cdot \frac{\partial B}{\partial y}$$

Modified duration and convexity are not well suited for analyzing bond portfolios since they are non-additive.

⇒ The modified duration and the convexity of a portfolio made of positions in different bonds are not equal to the sum of the modified durations or of the convexities, respectively, of the bond positions.

Dollar duration and **dollar convexity** are additive and can be used to measure the sensitivity of bond portfolios with respect to parallel changes in the zero rate curves.

Dollar Duration of a bond is defined as

$$D_{\$} = -\frac{\partial B}{\partial y},$$

and measures the sensitivity of the bond price with respect to small changes of the bond yield. It is easy to see that $D_{\$} = B \times D$.

Dollar Convexity

$$C = \frac{1}{B}\frac{\partial^2 B}{\partial y^2}$$

Dollar Convexity of a bond is defined as

$$C_\$ = \frac{\partial^2 B}{\partial y^2},$$

and measures the sensitivity of the dollar duration of a bond with respect to small changes of the bond yield. It is easy to see that $C_\$ = B \times C$.

Note that the change in dollar amount of a bond is related to dollar duration and dollar convexity as

$$\Delta B \approx -D_\$ \Delta y + \frac{C_\$}{2} \cdot (\Delta y)^2$$

$$\frac{\Delta B}{B} \simeq -D \, \Delta y + \frac{C}{2} (\Delta y)^2$$

Duration *vs* Convexity

The duration of a bond is a measure of how long on average the holder of the bond has to wait before receiving cash payments.

- A zero-coupon bond that lasts n years has a duration of n years.
- However, a coupon-bearing bond lasting n years has a duration of less than n years, because the holder receives some of the cash payments prior to year n.
- The duration is therefore a weighted average of the times when payments are made.

The convexity of a bond portfolio tends to be greatest when the portfolio provides payments evenly over a long period of time. It is least when the payments are concentrated around one particular point in time.

- By matching convexity as well as duration, a company can make itself immune to relatively large parallel shifts in the zero curve. However, it is still exposed to nonparallel shifts.

DV01

$D_\$ = -\frac{\partial B}{\partial y} \simeq -\frac{\Delta B}{\Delta y} \Rightarrow \Delta B = -D_\$ \cdot \Delta y$
$= -D_\$ \cdot 0.0001$
$= \frac{D_\$}{10000}$

DV01 stands for **"dollar value of one basis point"**, and is often used instead of dollar duration when quoting the risk associated with a bond position or with a bond portfolio.

The DV01 of a bond measures the change in the value of the bond for a decrease of one basis point (i.e. 0.01% or 0.0001) in the yield of the bond:

$$DV01 = \frac{D_\$}{10,000}.$$

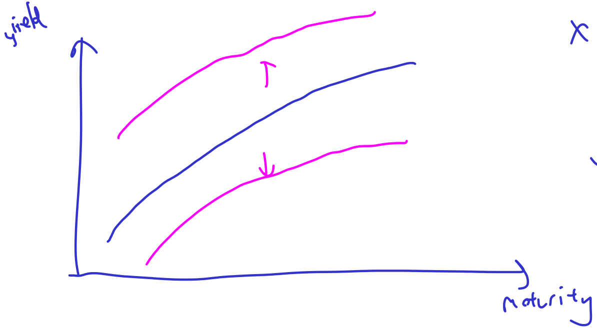
The DV01 of a bond is always positive, since a decrease in the bond yield results in an increase in the value of the bond:

$$\Delta B \approx DV01 \text{ for } \Delta y = -0.0001.$$

DV01 *vs* Modified Duration

⇒ DV01 is useful in a hedging context – when you want to offset price movement between your portfolio with a hedging instrument.

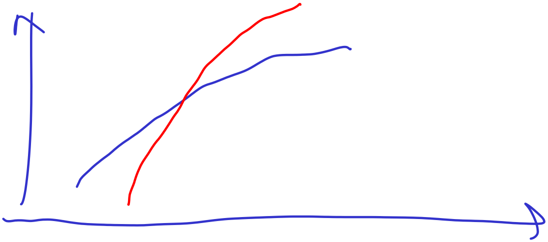
⇒ Modified Duration is useful when comparing how sensitive different bonds are to yields.



$X < Y$

X. B 30y bonds

Y. B 1y bonds



DV01

Example A $2y$ coupon bond is trading at 102. The continuously compounded yield is 5.2756%, and the coupon is 6.5 paid annually. Calculate the DV01 of this bond.

ans.: 0.0198

$$DV01 = \frac{D_\$}{10000} = \frac{\overset{102}{B} \cdot \overset{1.96}{D}}{10000}$$

SMU
SINGAPORE MANAGEMENT UNIVERSITY

Session 2: Interest Rate and Swap Market

Tee Chyng Wen

QF605 Fixed Income Securities

Case Study: LIBOR Origin

Created in 1969 by Minos Zombanakis in London, who arranged an \$80 million syndicated loan for the Shah of Iran.

$\Rightarrow$ The first loan to charge a floating rate, split among a group of banks.

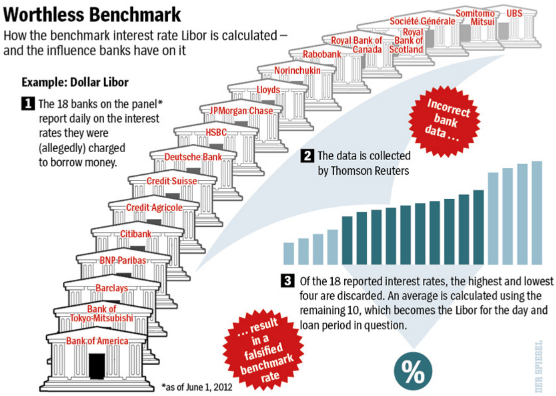
Subsequently became the benchmark for loans or bonds pricing.

Starting in 1980s, it became also the benchmark for complex derivatives.

Up until just before the 2008 crisis, LIBOR has become a rate that reflects the cost of unsecured borrowing for a specific period (generally $3m$ or $6m$).

Case Study: LIBOR Scandal

Source: Der Spiegel



Case Study: How was LIBOR calculated?

- Everyday, the Intercontinental Exchange (ICE) surveys a panel of banks asking the question

  At what rate could you borrow funds, were you to do so by asking for and then accepting inter-bank offers in a reasonable market size just prior to 11 am?

- Throw away the highest and lowest portion of the responses (4 each for USD LIBOR), and averages the remaining middle (10 for USD LIBOR).
- The average is reported at 11:30 am and published worldwide by Thomson Reuters.
- This process is carried out for 10 currencies for maturity up to 1 year.

Case Study: How was LIBOR rigged?

Panel A: Proper Submission

Bank	Rate	Quartile
1	5.00%	Upper 25%
2	4.90%	Upper 25%
3	4.80%	Upper 25%
4	4.70%	Upper 25%
5	4.60%	Included
6	4.50%	Included
7	4.40%	Included
8	4.30%	Included
9	4.20%	Included
10	4.10%	Included
11	4.00%	Included
12	3.90%	Included
13	3.80%	Included
14	3.70%	Included
15	3.60%	Lower 25%
16	3.50%	Lower 25%
17	3.40%	Lower 25%
18	3.30%	Lower 25%

Calculated LIBOR: 4.15%

Panel B: Misrepresentation of Rate

Bank	Rate	Quartile
1	5.00%	Upper 25%
2	4.90%	Upper 25%
3	4.80%	Upper 25%
4	4.70%	Upper 25%
5	4.60%	Included
6	4.50%	Included
7	4.40%	Included
8	4.30%	Included
9	4.20%	Included
10	4.10%	Included
11	4.00%	Included
12	3.90%	Included
13	3.80%	Included
14	3.70%	Included
15	3.60%	Lower 25%
16	3.50%	Lower 25%
17	3.40%	Lower 25%
18	3.30%	Lower 25%

Misrepresented as 3.35%

Panel C: Understatement of LIBOR

Bank	Rate	Quartile	
1	5.00%	Upper 25%	
3	4.80%	Upper 25%	
4	4.70%	Upper 25%	
5	4.60%	Upper 25%	Improperly excluded
6	4.50%	Included	
7	4.40%	Included	
8	4.30%	Included	
9	4.20%	Included	
10	4.10%	Included	
11	4.00%	Included	
12	3.90%	Included	
13	3.80%	Included	
14	3.70%	Included	
15	3.60%	Included	Improperly included
16	3.50%	Lower 25%	
17	3.40%	Lower 25%	
2	3.35%	Lower 25%	
18	3.30%	Lower 25%	

Calculated LIBOR: 4.05% — Understated result

If your "fair" rate is in the middle, you can raise or lower LIBOR by submitting a rate on the desired direction.

If your "fair" rate is on the upper end, you can only lower LIBOR, by submitting a low rate, and vice versa.

Case Study: Barclays' LIBOR Scandal

3 types of manipulation

1. Altering survey's response for the benefit of own derivative positions – requests from the trading desks.
2. Altering survey's reponse to protect Barclays' reputation – high submission rate is seen as a sign of weakness.
3. Attempting to induce other banks to alter their survey responses.

In short, the mechanism (trimmed mean) put in place to remove extreme values leaves survey participants with partial power to move rates in the direction they want.

Case Study: Recent LIBOR

2018

Every morning, a group of banks from around the world submits estimates of the lowest possible interest rate at which the institutions can borrow money from another bank on that day. There are five panels, each for a different currency, and every panel produces a rate for seven maturities, for a total of 35 rates a day. Below are the rates submitted on July 29 for U.S. dollar-denominated loans with a three-month maturity.

RABOBANK	0.70000
JPMORGAN CHASE	0.70000
SOCIETE GENERALE	0.72000
ROYAL BANK OF CANADA	0.72000
CITIGROUP	0.72500
BANK OF AMERICA	0.73000
HSBC	0.73000
UBS	0.73100
BANK OF TOKYO-MITSUBISHI	0.76000
CREDIT SUISSE	0.76000
ROYAL BANK OF SCOTLAND	0.77500
BARCLAYS	0.78000
SUMITOMO MITSUI FINANCIAL GROUP	0.79000
NORINCHUKIN	0.81000
BNP PARIBAS	0.81000
LLOYDS	0.84000
CREDIT AGRICOLE	0.86250
DEUTSCHE BANK	0.90000

The top and bottom quarter of submissions are discarded to avoid outliers. There were 18 contributors, so the highest and lowest four were cut.

RABOBANK	0.70000
JPMORGAN CHASE	0.70000
SOCIETE GENERALE	0.72000
ROYAL BANK OF CANADA	0.72000
CITIGROUP	0.72500
BANK OF AMERICA	0.73000
HSBC	0.73000
UBS	0.73100
BANK OF TOKYO-MITSUBISHI	0.76000
CREDIT SUISSE	0.76000
ROYAL BANK OF SCOTLAND	0.77500
BARCLAYS	0.78000
SUMITOMO MITSUI FINANCIAL GROUP	0.79000
NORINCHUKIN	0.81000
BNP PARIBAS	0.81000
LLOYDS	0.84000
CREDIT AGRICOLE	0.86250
DEUTSCHE BANK	0.90000

Source: Bloomberg

Case Study: LIBOR Replacement

After the crisis, the market for unsecured inter-bank lending failed to recover – most daily LIBOR submissions are based on "expert judgement".

US central bank data shows that in the 2^{nd} quarter in 2018, the median number of unsecured borrowing was 7.

$\Rightarrow$ Many may not be aware of how truly thin these markets have become.

Case Study: LIBOR Replacement

Central banks in different economies started to look for alternative rates to be used instead of LIBOR-style reference rates.

- USD: **S**ecured **O**vernight **F**inancing **R**ate (SOFR), the Treasury repo rate for overnight loan. Daily average of US Treasury-collateralized overnight repurchase agreement (repo) transaction data collected by the US Federal Reserve
- GBP: **S**terling **O**ver **N**ight **I**ndex **A**verage (SONIA), which tracks the actual (unsecured) overnight deals in money markets.
- JPY: **T**okyo **O**ver **N**ight **A**verage **R**ate (TONAR), unsecured overnight rate published by Bank of Japan.
- CHF: **S**wiss **A**verage **R**ate **O**ver**N**ight (SARON), based on CHF repo market.
- EUR: **E**uro **S**hort **T**erm **R**ate (€STER), based on actual money market transactions.
- SGD: **S**ingapore **O**vernight **R**ate **A**verage (SORA). Determined by the volume-weighted average rate of borrowing transactions in the unsecured overnight interbank SGD cash market in Singapore.

Case Study: LIBOR Replacement and Fallback

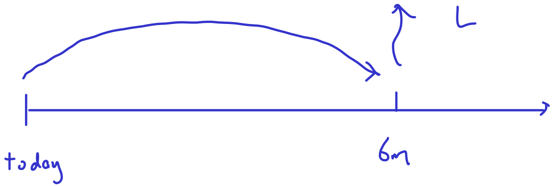
The USD LIBOR panel has ended on 30-June-2023. Some ($1m$, $3m$, $6m$) Synthetic LIBORs will continue to be published until 30-Sep-2024. The Alternative Reference Rates Committee (ARRC) recommended the US Secured Overnight Financing Rate (SOFR) to replace the USD LIBOR.

Main LIBOR transition issues to be addressed due the **term mismatch** and the **credit sensitivity**:

- ⇒ SOFR is an **overnight** rate while LIBOR is a **term** rate. SOFR must be compounded daily for a period to arrive at a simple interest rate.
- ⇒ LIBOR is paid in arrears but set in advance, so it involves expectation of future short rates.
- ⇒ Different **credit exposure**.

The International Swaps and Derivatives Association (ISDA) has provided **collateral agreement** interest rate definitions that incorporate these new **risk-free rates** (RFRs):

- ⇒ SOFR to replace Effective Federal Funds Rate (EFFR) for USD
- ⇒ €STR to replace the Euro Overnight Index Average (EONIA)



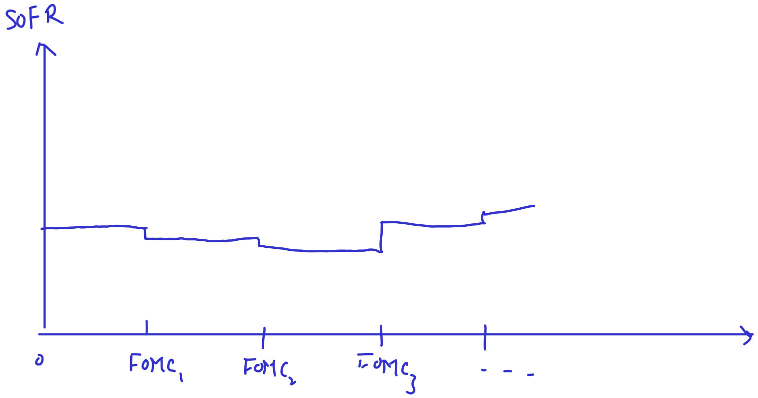
$$(1+r_1)\cdot(1+r_2)(1+r_3)\cdots(1+r_n) = (1+R)^n$$

Case Study: LIBOR Replacement and Fallback

The ARRC also indicated support for the use of the **CME Term SOFR Rates** in areas where use of overnight or averages of SOFR has proven to be difficult:

- The CME Term SOFR Rates aim to provide a robust measure of forward-looking SOFR term rates based on market expectations implied from transactions in the derivatives markets.
- The methodology for determining CME Term SOFR Rates uses a combination of SOFR **overnight indexed swaps** (OIS) and one-month and three-month SOFR **futures contracts**.
    - 1m SOFR futures (SR1): 13 consecutive months contracts
    - 3m SOFR futures (SR3): 5 consecutive quarterly contracts

  CME determines the path of overnight SOFR rates by assuming the overnight SOFR rates follow a **piecewise constant step function** and can only jump up or down the day after **FOMC policy rate announcement dates** and remains at those levels across all dates in between the FOMC policy rate announcement dates.
- No expert judgement is required.


SOFR
0
$FOMC_1$
$FOMC_2$
$FOMC_3$
- - -

Case Study: LIBOR Replacement and Fallback

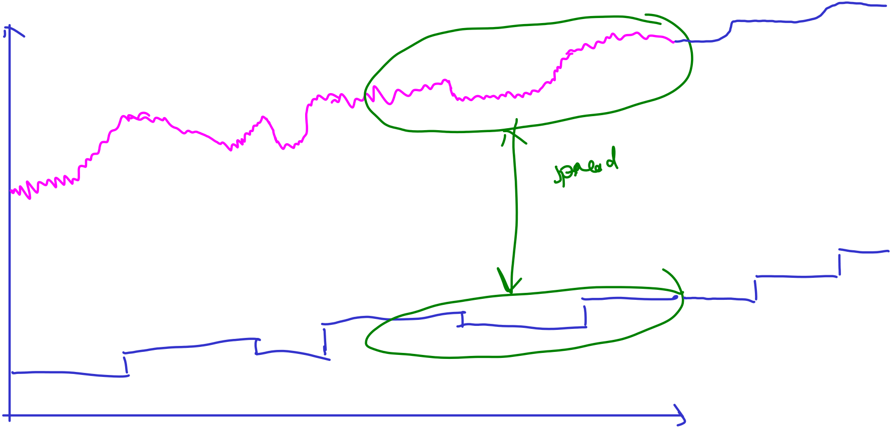
	Term SOFR	Overnight SOFR
Tenor	1m, 3m, 6m, 12m	Overnight compounded
Source	CME Group	New York Fed
Term	Forward-looking	Backward-looking rate
Fixing	Known before period starts	Determine after period ends
Pros	Similar to LIBOR	Consistent with other currencies
Cons	Missing for other currencies	Interest payable unknown when loan begins

Case Study: LIBOR Replacement and Fallback

LIBOR fallback To substitute the LIBOR fixing in the derivatives by a new quantity obtained as the sum of an **adjusted RFR** and an **adjustment spread**.

- The adjusted RFR plays the role of the floating term rate—it will depend on an overnight benchmark and be known around the date where LIBOR should have been fixed.
- The adjustment spread will be decided after the discontinuation and be seen as an adjustment to avoid **value transfer** between the original LIBOR fixing and the new fixing mechanism.

Historical mean/median approach The spread adjustment is based on the mean or median spot spread between the LIBOR and the adjusted RFR calculated over a signficant, static lookback period prior to the relevant announcement or publication triggering the fallback provisions.

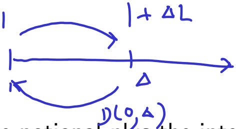

spread

Term Rate: LIBOR & Its Replacement

If you put your money in a money-market account for a given period, the interest earned over this period is quoted as a **term rate** (e.g. LIBOR). At the end of a period of length Δ, one receives an interest equal to $\Delta \times L$, where L denotes the term rate and Δ denotes the day count fraction.

Since L is always quoted as <u>annualized rate</u>, Δ is often referred to as the **accrual fraction** or **day count fraction**.

We have $1 \equiv (1 + \Delta \cdot L) \cdot D(0, \Delta)$.



This just states that the present value today of the notional plus the interest earned at the end of the Δ period is equal to the notional.

Note that in real markets Δ is not exactly equal to 0.25, 0.5, or 1, but is calculated according to a specific method for a given market, known as the **day count convention** (e.g. Act/365, Act/360 etc.)

Term Rate (LIBOR) Market

$D(t,T)$ $1+\Delta L$

t T $T+\Delta$

$D(t,T+\Delta)$

A **forward term rate** (e.g. forward LIBOR) is the interest rate one can contract for at time t to put money in a money-market account for the time period $[T, T+\Delta]$. Then we have

$$D(t,T) = (1 + \Delta \cdot L) \cdot D(t, T+\Delta)$$

At the time when the **forward LIBOR** is fixed, it is then called a **spot LIBOR**. *Note that LIBOR is fixed at the beginning of each period T_i, and paid at the end of the period T_{i+1}. We call this* **"fixed in advance, paid in arrears."**

In most markets, only forward LIBOR rates of one specific tenor are actively traded, which is usually $3m$ (e.g. USD) or $6m$ (e.g. SGD, GBP, EUR).

Everyday we have a large number of forward LIBOR rates with this specific tenor, we can denote them as

$$i = 1, 2, \cdots, N: \; L(T_i, T_{i+1})$$

Forward Rate Agreements (FRA)

Suppose you agree to an interest rate today, which you will obtain on an amount of money invested at later date, that is returned with interest at an even later date.

This kind of agreement is called a **forward rate agreement (FRA)**.

This level of the agreed rate that makes the value of entering into a forward rate agreement equal to zero is called the **forward rate**.

You have cashflow liability in the future (e.g need to borrow or deposit cash) but do not want to be exposed to interest rate risks.

Under a FRA contract:

- **Buyer** is obligated to **borrow** money at a pre-determined or fixed interest rate on the date when the FRA expires.
- **Seller** is obligated to **lend** at the fixed FRA rate. Thus both counterparties lock in a rate in advance and the actual lending and borrowing is done at the FRA expiration date.

1x7

2x8

Forward Rate Agreements (FRA)

3x9

FRA allows you to **lock-in an interest rate today** at which you can borrow or deposit in the future.

4x10

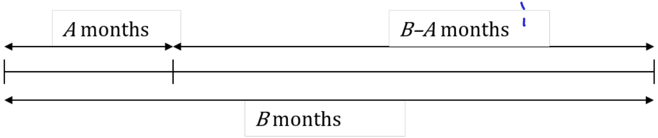
- ⇒ For borrowers, if the market rate ends up higher, then it is good for you. The opposite is true for lenders.

5x11

- ⇒ For borrowers, if the market rate ends up lower, then it is bad for you. The opposite is true for lenders.

6x12

⋮



The FRA is quoted as $A \times B$ in terms of months. For example, a 3×9 FRA means the forward contract expires in 3 months, and the underlying interest rate is a 6-month LIBOR.