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CFA® Program Level I

Fixed Income Cheat Sheet

2027 curriculum · 19 readings · 62 formulas

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CFA® PROGRAM LEVEL I · CHEAT SHEET

Fixed Income

Exam weight 11–14% · 19 readings · 62 formulas

51 Fixed-Income Instrument Features

- The coupon rate is the annual percentage of par paid as interest, so each periodic coupon equals the coupon rate times par value divided by the number of payments per year.
- A bond with an original maturity of one year or less is a money market security, one with an original maturity of more than one year is a capital market security, and a bond with no stated maturity is a perpetual bond.
- A zero-coupon (pure discount) bond pays no interest before maturity and is sold at a discount to par, so the investor's whole return is the gap between the price paid and the par value received.
- For a fixed-coupon bond, price and yield move in opposite directions; a premium bond yields less than its coupon rate and a discount bond yields more.
- Senior debt ranks ahead of junior (subordinated) debt in bankruptcy or liquidation, so junior debt carries more credit risk and must offer a higher yield.
- A bond's spread is its extra yield over a government bond of the same maturity, with the government yield curve used as the benchmark.
- The bond indenture (trust deed) is the legal contract between issuer and bondholders; it sets out the sources of repayment, any collateral, credit enhancements and the covenants.
- Affirmative covenants state what the issuer must do, including cross-default and pari passu clauses; negative covenants restrict what the issuer may do, including the negative pledge clause and limits subject to an incurrence test.

EXAM SHORTCUTS

- A bond priced above par has a yield below its coupon rate, and a bond priced below par has a yield above it, so comparing the price with par answers a yield-versus-coupon question without any calculation.

52 Fixed-Income Cash Flows and Types

- A bullet bond pays only interest before maturity and repays all principal at maturity; a fully amortizing bond's level payments retire the debt by the last payment; a partially amortizing bond's level payments leave a balloon payment at maturity.
- A sinking fund provision obliges the issuer to retire part of the issue on a set schedule, which lowers bondholders' credit risk but adds reinvestment risk.
- A floating-rate note pays the market reference rate plus a fixed margin, so its per-period coupon is (MRR + margin) divided by the number of payments per year.
- A capital-indexed bond such as TIPS keeps a fixed coupon rate, effectively a real rate, and adjusts its principal for inflation, so each coupon is that rate applied to the adjusted principal; an interest-indexed bond adjusts the coupon rate and leaves the principal unprotected.

- An embedded option benefits whoever holds the right to exercise it: callable bond = straight bond − call, with a higher yield, and putable bond = straight bond + put, with a lower yield.
- For a convertible bond, the conversion ratio is par divided by the conversion price, and the conversion value is the conversion ratio times the current share price.
- A foreign bond is issued by a foreign issuer and traded in another country's domestic market, while a Eurobond is issued beyond the jurisdiction of any single country and may be denominated in any currency.
- On an original issue discount bond such as a zero-coupon bond, the rise in value toward par is interest, and many jurisdictions tax part of the discount each year as interest income even though no cash is received.

EXAM SHORTCUTS

- A partially amortizing payment uses the same calculator entries as the fully amortizing payment, with the balloon entered as FV instead of zero.
- Only a zero-coupon bond held to maturity has no reinvestment risk, so any coupon bond can be eliminated from that answer even if it is held to maturity.
- A callable bond is worth less and a putable bond more than an otherwise identical straight bond, so the three can be ranked by price, and in reverse by yield, without valuing any of them.

53 Fixed-Income Issuance and Trading

- Bond markets are segmented mainly by type of issuer (sector), credit quality and original maturity.
- Investment grade means a rating from AAA down to BBB− at S&P, or from Aaa down to Baa3 at Moody's; a rating of BB+ or below (Ba1 or below at Moody's) is high yield.
- Exam convention: money market securities have an original maturity of one year or less, intermediate-term ones between 1 and 10 years, and long-term ones more than 10 years; current practice applies the money market label to instruments issued with maturities of up to about one year, such as Treasury bills, commercial paper and repos.
- Fallen angels are bonds of issuers downgraded from investment grade to high yield because their credit quality deteriorated, while distressed debt is the debt of issuers that are in bankruptcy or expected to file for it.
- A well-established investment-grade company can fund short-term (including seasonal) working capital with commercial paper, medium-term investments and permanent working capital with intermediate-term debt, and fixed-asset investment with long-term debt.
- Compared with equity indexes, bond indexes have many more constituents and higher turnover, tracker funds use sampling, and broad bond indexes usually carry large weights in sovereign bonds.
- In an underwritten offering the intermediaries guarantee the issue price; in a best-efforts offering they earn a commission with no price guarantee; a shelf registration registers the aggregate amount once and lets the bonds be issued over time.
- Most secondary bond trading takes place in over-the-counter dealer markets, and the dealer's spread between ask and bid widens as liquidity falls: a fraction of 1 bp for on-the-run sovereign debt of developed markets, and 10–20 bp or more for seasoned, smaller or less liquid corporate issues.

54 Fixed-Income Markets for Corporate Issuers

- Lines of credit become more reliable from uncommitted to committed to revolving; committed and revolving lines carry a commitment fee and revolving lines usually add restrictive covenants, while an uncommitted line usually costs only interest on the amount drawn.
- Factoring transfers receivables, with the credit-granting and collection functions, to a factor at a discount to face value, whereas assigning receivables as collateral keeps them with the borrower as security for a loan.
- Commercial paper is short-term unsecured debt issued by large, highly rated firms, usually maturing in under three months, and issuers manage its rollover risk with backup lines of credit.

- In a repo the security seller borrows cash and the security buyer lends it against the security; $\text{purchase price} = \text{market value of collateral}/\text{initial margin}$ and $\text{repurchase price} = \text{purchase price} \times (1 + \text{repo rate} \times \text{days}/360)$.
- $\text{Variation margin} = \text{initial margin} \times \text{adjusted purchase price} - \text{market value of collateral}$; a negative figure means the loan is overcollateralized and the borrower may ask for collateral back.
- The repo rate is higher when alternative money market rates are higher, when the term is longer and longer rates exceed short rates, and when the repo is undercollateralized or collateral is not delivered; it is lower for higher-quality collateral and for collateral in high demand or low supply.
- With a normal yield curve, both investment-grade and high-yield issuers pay higher yields at longer maturities, and the increase is bigger for high-yield issuers because their credit spreads are larger.
- Compared with investment-grade issues, high-yield issues carry more covenants, are often secured, usually mature in 10 years or less, more often allow early repayment through callable bonds or prepayable leveraged loans, and have more equity-like returns.

EXAM SHORTCUTS

- The haircut depends only on the initial margin, $1 - 1/\text{initial margin}$, so it can be found without the collateral value, the repo rate or the term.

FORMULAS

Repurchase agreements

$$\text{purchase price} = \frac{\text{market value of collateral}}{\text{initial margin}}$$

$$\text{repurchase price} = \text{purchase price} \times \left(1 + \text{repo rate} \times \frac{\text{days}}{360}\right)$$

$$\text{haircut} = \frac{\text{market value} - \text{purchase price}}{\text{market value}} = 1 - \frac{1}{\text{initial margin}}$$

$$\text{variation margin} = \text{initial margin} \times \text{adjusted purchase price} - \text{market value of collateral}$$

55 Fixed-Income Markets for Government Issuers

- Sovereign bonds are backed by the power to tax, so they usually carry the highest credit rating in their home market, and the sovereign is usually the largest issuer there.
- External debt of an emerging market government in a reserve currency spares foreign investors the direct currency risk but leaves indirect currency risk, because the government must earn enough of that currency to repay.
- Ricardian equivalence would make a government indifferent to the maturity of its debt only if taxpayers save more when they expect higher taxes, have rational expectations, borrow and lend without transaction costs and pass tax savings on to future generations; these conditions do not hold, so governments keep a fairly stable mix of short- and long-term debt.
- Short-term sovereign debt is seen as safe and highly liquid, which likely holds its yields down, but relying on it too heavily creates rollover risk; longer-term sovereign debt supplies the benchmark yields used to price other borrowers' credit risk.
- General obligation bonds are backed by local taxing power, revenue bonds are repaid from the fees of the one project they fund, agency (quasi-government) bonds are issued by entities a national government creates, and supranational bonds are issued by institutions set up by several sovereign governments.
- In a government bond auction, noncompetitive bids are filled first, then competitive bids from the highest price (lowest yield) down until the offering is used up; the cut-off yield is the highest accepted yield, which matches the lowest accepted price.

- In a single-price auction every successful bidder pays the price at the cut-off yield, while in a multiple-price auction each successful competitive bidder pays its own bid.
- On-the-run government bonds, the most recently issued of each maturity, trade most actively and supply the default-risk-free benchmark yields, and demand from holders with noneconomic objectives pushes sovereign yields below non-sovereign yields.

56 Fixed-Income Bond Valuation: Prices and Yields

- A bond's price is the present value of its coupons and principal discounted at the YTM; a semiannual bond uses the coupon $C/2$, the periodic rate $YTM/2$ and $2N$ periods.
- A quoted YTM is a stated annual rate, the periodic yield times the number of periods per year, and it is an effective annual rate only for an annual-pay bond.
- An investor earns the YTM only if the bond is held to maturity, the issuer makes every promised payment and each coupon is reinvested at that same YTM.
- Between coupon dates, the full price is the value on the last coupon date compounded at the periodic YTM, $PV^{full} = PV_0 \times (1+r)^{t/T}$; accrued interest is $t/T \times PMT$, and subtracting accrued interest from the full price gives the flat (quoted) price.
- Accrued interest is usually counted on an actual/actual basis for government bonds and on a 30/360 basis for corporate bonds.
- A bond whose coupon rate is above its YTM trades at a premium, one whose coupon equals its YTM trades at par, and one whose coupon is below its YTM trades at a discount.
- For option-free bonds, other things equal, a lower coupon and a longer maturity make the price more sensitive to a yield change, and convexity makes the price rise from a yield fall larger than the price drop from an equal yield rise.
- Matrix pricing estimates the YTM of a bond that is not traded or trades infrequently from the yields of traded bonds with very similar credit quality, coupon and maturity, interpolating linearly between the maturities that bracket the target.

EXAM SHORTCUTS

- Comparing the coupon rate with the YTM shows whether the price is above, at or below par before any calculation, so answer choices on the wrong side of par can be ruled out at once.
- If a discount bond's price is unchanged after time has passed, its YTM must have risen, and if a premium bond's price is unchanged, its YTM must have fallen; no repricing is needed to answer the direction question.

FORMULAS

Price = present value of the promised cash flows

$$P = \frac{C}{(1+YTM)} + \frac{C}{(1+YTM)^2} + \cdots + \frac{C+FV}{(1+YTM)^N}$$

$$P = \sum_{t=1}^{2N} \frac{C/2}{(1+YTM/2)^t} + \frac{FV}{(1+YTM/2)^{2N}}$$

Accrued interest, flat price and full price

$$AI = \frac{t}{T} \times PMT$$

Matrix pricing

$$YTM_{target} = YTM_{short} + \frac{T_{target} - T_{short}}{T_{long} - T_{short}} (YTM_{long} - YTM_{short})$$

57 Yield and Yield Spread Measures for Fixed-Rate Bonds

- For a bond that pays more than once a year, the quoted YTM is the periodic yield times the number of periods per year; for a semiannual-pay bond this is the semiannual bond basis.

- $EAY = (1 + \text{stated annual yield}/n)^n - 1$; holding the EAY constant, a higher periodicity means a lower stated yield, and holding the stated yield constant, a higher periodicity means a higher EAY.
- Current yield is the annual cash coupon divided by the flat price and ignores capital gains, losses and reinvestment income; simple yield adds the straight-line amortization of a discount, or subtracts that of a premium, before dividing by the flat price.
- For an option-free bond priced at a discount, coupon rate < current yield < YTM; at a premium the order reverses, and at par all three are equal.
- A yield to call uses the periods to the call date and the call price in place of maturity and par, and the yield to worst is the lowest of the YTM and all the yields to call.
- A G-spread is the bond's yield minus a government benchmark yield of the same maturity, interpolated if needed, while an I-spread is measured against the swap rate of the same currency and tenor.
- The Z-spread is the constant spread that, added to every benchmark spot rate, discounts the bond's cash flows to its market price, and it equals the G-spread when the spot curve is flat.
- $\text{OAS} = \text{Z-spread} - \text{option value}$; for a callable bond the OAS is below the Z-spread, and for an option-free bond the two are equal.

EXAM SHORTCUTS

- For an option-free bond, the price relative to par fixes the order of coupon rate, current yield and YTM, so a ranking question needs no yield calculation.
- A yield to call reuses the YTM inputs; only N, set to the periods to the call date, and FV, set to the call price, change.
- When the spot curve is flat, the Z-spread equals the G-spread, so no trial-and-error search is needed.

FORMULAS

Periodicity and the effective annual yield	$EAY = \left(1 + \frac{\text{stated annual yield}}{n}\right)^n - 1$ $\text{stated yield}_m = m\left[(1 + EAY)^{1/m} - 1\right]$
Current yield and simple yield	$\text{current yield} = \frac{\text{annual cash coupon}}{\text{flat price}}$ $\text{simple yield} = \frac{\text{annual coupon} \pm \text{straight-line amortization}}{\text{flat price}}$
Option-adjusted price and option-adjusted yield	$\text{callable bond value} = \text{straight bond value} - \text{call option value}$
Z-spread	$\text{price} = \sum_{t=1}^{N} \frac{CF_t}{(1 + S_t + Z)^t}$
Option-adjusted spread (OAS)	$\text{OAS} = \text{Z-spread} - \text{option value (bp)}$ $\text{option value} = \text{Z-spread} - \text{OAS}$

58 Yield and Yield Spread Measures for Floating-Rate Instruments

- An FRN's coupon rate is reset each period to the market reference rate set at the start of the period plus the quoted margin, and the coupon is paid at the end of the period, in arrears.
- The quoted margin is fixed in the indenture and reflects the issuer's credit risk at issuance, while the discount (required) margin is the spread investors currently require, the margin that would make the FRN worth par on a reset date.

- On a reset date an FRN trades at par when QM = DM, below par when DM > QM because credit quality has worsened, and above par when DM < QM because credit quality has improved.
- While the issuer's credit quality is unchanged, the QM stays equal to the DM; neither the passage of time nor a change in the MRR opens a gap between them.
- The simplified FRN valuation projects each coupon at today's MRR plus the QM and discounts at today's MRR plus the DM, both divided by the periods per year, and it ignores expected changes in the MRR.
- US Treasury bills and commercial paper are quoted as discount yields on a 360-day year, computed on face value, while the convention for bank CDs, repos and market reference rates is an annualized add-on rate.
- A money market instrument's BEY annualizes the add-on return over a 365-day year, $HPY \times 365/\text{days}$, and for a discount instrument priced below face value it is higher than the quoted discount yield.
- To compare a money market yield with a semiannual-pay bond's YTM, compound the HPY to an effective annual yield, $(1+HPY)^{365/\text{days}}-1$, and restate it as $2[(1+EAY)^{1/2}-1]$.

EXAM SHORTCUTS

- An FRN priced below par on a reset date must have DM > QM, and one priced above par must have DM < QM, so answer choices on the wrong side of the quoted margin can be eliminated without solving for I/Y.
- An add-on yield quoted on a 360-day basis converts to a 365-day basis, the BEY, by multiplying by 365/360; the holding period yield is not needed.

FORMULAS

Simplified valuation on a reset date

$$V=\sum_{t=1}^{N}\frac{(\text{MRR}+\text{QM})\times FV/m}{\left(1+\frac{\text{MRR}+\text{DM}}{m}\right)^{t}}+\frac{FV}{\left(1+\frac{\text{MRR}+\text{DM}}{m}\right)^{N}}$$

Key formulas: money market yields

$$\text{Add-on yield (365-day)}=HPY\times\frac{365}{\text{days}}$$

$$\text{Discount yield}=\frac{FV-P}{FV}\times\frac{360}{\text{days}}$$

$$P=FV\times\left(1-\text{discount yield}\times\frac{\text{days}}{\text{year}}\right)$$

$$FV=PV\times\left(1+\text{add-on yield}\times\frac{\text{days}}{\text{year}}\right)$$

Comparing with a semiannual-pay bond

$$EAY=(1+HPY)^{365/\text{days}}-1$$

$$\text{semiannual bond basis}=2\left[(1+EAY)^{1/2}-1\right]$$

59 The Term Structure of Interest Rates: Spot, Par, and Forward Curves

- A spot rate is the market discount rate for a single payment at a future date, which is why it equals the YTM of a zero-coupon bond of that maturity.
- The no-arbitrage price of a bond discounts each cash flow at the spot rate for its own date, and the bond's YTM is the internal rate of return at that price, not a simple or geometric average of the spot rates.
- A par rate is the coupon rate at which a bond of a given maturity would be priced at par, given the spot curve.
- ${}_{A\text{y}B\text{y}}=\left[(1+S_{A+B})^{A+B}/(1+S_A)^{A}\right]^{1/B}-1$, where the $1/B$ root annualizes a multi-year forward rate.
- A spot rate is the geometric mean of the one-period rates up to its maturity: $S_N=\left[(1+S_1)(1+{}_{1y1y})\cdots(1+{}_{(N-1)y1y})\right]^{1/N}-1$.
- Discounting each cash flow by the compounded chain of one-period forward rates up to its date gives the same no-arbitrage price as discounting at spot rates.

- Beyond the first year, forward > spot > par when the curve is normal (upward-sloping), forward < spot < par when it is inverted, and all three are equal when it is flat.
- The par curve and the forward curve are derived from the spot curve, while the yield curve for coupon bonds is observed from the YTMs of actively traded bonds, with gaps filled by linear interpolation.

EXAM SHORTCUTS

- A forward rate is roughly the difference of the total rates, for example $2y1y \approx 3S_3 - 2S_2$; the exact figure needs compounding, but the approximation screens out wrong answer choices quickly.
- To find a par rate from answer choices, plug in the middle choice: a price below 100 means the par rate is higher, and a price above 100 means it is lower.

FORMULAS

Pricing with spot rates	$P = \frac{PMT}{(1+S_1)} + \frac{PMT}{(1+S_2)^2} + \cdots + \frac{PMT+FV}{(1+S_N)^N}$
Par rates	$100 = \frac{c}{1+S_1} + \frac{c}{(1+S_2)^2} + \cdots + \frac{c+100}{(1+S_N)^N} \Rightarrow c = \frac{100\left[1 - \frac{1}{(1+S_N)^N}\right]}{\sum_{t=1}^{N} \frac{1}{(1+S_t)^t}}$
Forward rates and notation	$(1+S_3)^3 = (1+S_1)(1+{}_{1y1y})(1+{}_{2y1y}) = (1+S_2)^2(1+{}_{2y1y})$ $S_N = \left[(1+S_1)(1+{}_{1y1y})\cdots(1+{}_{(N-1)y1y})\right]^{1/N} - 1$ ${}_{A\text{y}B\text{y}} = \left[\frac{(1+S_{A+B})^{A+B}}{(1+S_A)^A}\right]^{1/B} - 1$
Valuing a bond with forward rates	$P = \frac{PMT}{1+S_1} + \frac{PMT}{(1+S_1)(1+{}_{1y1y})} + \frac{PMT+FV}{(1+S_1)(1+{}_{1y1y})(1+{}_{2y1y})}$

60 Interest Rate Risk and Return

- A fixed-rate bond's return comes from the promised coupons and principal, the income from reinvesting coupons, and any capital gain or loss on a sale before maturity.
- With every payment made on time and coupons reinvested at the YTM, the realized return equals the YTM at purchase whether the bond is kept until it matures or sold earlier at an unchanged YTM.
- Higher yields lower the sale price but raise reinvestment income; over a short horizon market price risk dominates, and over a long horizon reinvestment risk dominates.
- A capital gain or loss is the sale price minus the carrying value on the constant-yield price trajectory, so movement along that trajectory counts as interest income rather than as a gain or loss.
- When the investment horizon equals the bond's Macaulay duration, a one-time change in YTM right after purchase leaves the horizon yield approximately equal to the YTM at purchase.
- Duration gap = Macaulay duration − investment horizon; a positive gap leaves the investor exposed to rising rates through price risk, and a negative gap leaves the investor exposed to falling rates through reinvestment risk.
- Macaulay duration is the weighted average time until a bond's cash flows are received, with each weight equal to the cash flow's present value at the YTM divided by the full price; a coupon bond's Macaulay duration is shorter than its maturity.
- Other things equal, reinvestment risk is greater for bonds with higher coupons and longer maturities, and a zero-coupon bond held to maturity has none.

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EXAM SHORTCUTS

- For a bond held to maturity after a one-time change in YTM right after purchase, the realized return lies between the original YTM and the new reinvestment rate, so any answer outside that range can be ruled out.
- A zero-coupon bond's Macaulay duration equals its maturity, so it needs no weighting calculation.

FORMULAS

Horizon yield	$$\text{Horizon yield} = \left(\frac{\text{sale price (or principal)} + \text{coupons} + \text{reinvestment income}}{\text{purchase price}}\right)^{1/H} - 1$$
Holding period return, Macaulay duration and the investment horizon	$$\text{Duration gap} = \text{Macaulay duration} - \text{investment horizon}$$
Calculating and interpreting Macaulay duration	$$\text{MacDur} = \sum_{t=1}^{N} t \times w_t$$ $$w_t = \frac{CF_t/(1+r)^t}{\text{full price}}$$ $$\sum_t w_t = 1$$

61 Yield-Based Bond Duration Measures and Properties

- $\text{ModDur} = \text{MacDur}/(1+r)$, where r is the periodic yield ($YTM/2$ for a semiannual-pay bond with durations in years), so with a positive yield modified duration is smaller than Macaulay duration.
- $\%\Delta P \approx -\text{ModDur} \times \Delta\text{YTM}$; this straight-line estimate works well for small yield changes, and for large changes it understates the price rise when yields fall and overstates the price fall when yields rise.
- $\text{ApproxModDur} = (V_- - V_+)/(2 \times V_0 \times \Delta\text{YTM})$, with ΔYTM entered as the annual yield change in decimal form.
- Money duration is modified duration times the full price of the position, $\Delta V \approx -\text{Money duration} \times \Delta\text{YTM}$, and the PVBP, the change in full price for a 1 bp yield change, is approximately money duration × 0.0001.
- Other things equal, a higher coupon rate or a higher YTM lowers duration, and a longer maturity usually raises it; for discount bonds at long maturities, duration can fall as maturity rises toward the perpetuity duration $(1+\text{YTM})/\text{YTM}$.
- A zero-coupon bond's Macaulay duration equals its maturity, so for the same maturity and yield it has more interest rate risk than any coupon bond.
- A callable bond has a lower duration than an otherwise identical option-free bond, and a putable bond has less price volatility at high yields, where the put acts as a floor on its price.

EXAM SHORTCUTS

- A floating-rate note's Macaulay duration is roughly the time to its next reset date, whatever its final maturity, so no cash flow weighting is needed.
- When bonds on one price-yield chart have the same price at the current yield, the bond whose curve is steepest at that yield has the highest modified duration.

FORMULAS

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Modified duration	$\text{ModDur} = \dfrac{\text{MacDur}}{1+r} \quad (\text{annual-pay: } r = \text{YTM})$ $\text{ModDur} = \dfrac{\text{MacDur}}{1+\text{YTM}/2} \quad (\text{semiannual-pay, YTM on a semiannual bond basis, du}$ $\%\Delta P \approx -\text{ModDur} \times \Delta\text{YTM}$
Approximate modified duration	$\text{ApproxModDur} = \dfrac{V_- - V_+}{2 \times V_0 \times \Delta\text{YTM}}$
Money duration and PVBP	$\text{Money duration} = \text{ModDur} \times \text{full price of the position}$ $\text{Money duration per 100 of par} = \text{ModDur} \times \text{full price per 100}$ $\Delta V \approx -\text{Money duration} \times \Delta\text{YTM}$ $\text{PVBP} = \dfrac{V_- - V_+}{2}$ $\text{PVBP} \approx \text{Money duration} \times 0.0001$

62 Yield-Based Bond Convexity and Portfolio Properties

- Convexity measures the curvature of the price-yield relationship; for an option-free bond, duration alone understates the price gain when yields fall and overstates the price loss when yields rise.
- $\%\Delta PV^{Full} \approx -\text{AnnModDur} \times \Delta YTM + \frac{1}{2} \times \text{AnnConvexity} \times (\Delta YTM)^2$.
- Approximate convexity is $(V_- + V_+ - 2V_0)/[(\Delta YTM)^2 V_0]$.
- A longer maturity, a lower coupon and a lower yield raise convexity; with the same duration, more dispersed cash flows give more convexity.
- Callable bonds and mortgage-backed securities can have negative convexity at low yields; option-free bonds always have positive convexity.
- Money convexity is annual convexity × the full value of the position.
- Portfolio duration and convexity come either from the aggregate portfolio cash flows, the theoretically correct approach, or in practice as averages weighted by full market value, which give the portfolio's percentage change only for a parallel shift of the yield curve.

EXAM SHORTCUTS

- For an option-free bond the convexity adjustment is positive whether yields rise or fall.
- The convexity term grows with the square of the yield change, so doubling the change roughly quadruples it.

FORMULAS

Convexity from the cash flows	$\text{convexity}_t = \dfrac{t(t+1)}{(1+r)^2}$
Approximate convexity	$\text{approximate convexity} = \dfrac{V_- + V_+ - 2V_0}{(\Delta YTM)^2 V_0}$
Price change using duration and convexity	$\%\Delta PV^{Full} \approx -\text{AnnModDur} \times \Delta YTM + \frac{1}{2} \times \text{AnnConvexity} \times (\Delta YTM)^2$

Money convexity	$\text{MoneyCon} = \text{AnnConvexity} \times PV^{Full}$ of the position $\Delta PV^{Full} \approx -(\text{MoneyDur} \times \Delta YTM) + \frac{1}{2} \times \text{MoneyCon} \times (\Delta YTM)^2$

63 Curve-Based and Empirical Fixed-Income Risk Measures

- Yield-based duration and convexity assume fixed, known cash flows, so callable bonds, putable bonds and mortgage-backed securities are measured with effective duration and effective convexity against shifts in a benchmark yield curve.
- $\text{EffDur} = (V_- - V_+)/(2V_0\,\Delta\text{Curve})$ and $\text{EffCon} = (V_- + V_+ - 2V_0)/[(\Delta\text{Curve})^2\,V_0]$, with V_- and V_+ produced by a pricing model.
- Effective duration measures sensitivity to the benchmark curve only and holds the credit and liquidity spread constant, while modified duration does not separate benchmark changes from spread changes.
- A callable bond has negative convexity and a lower effective duration than the option-free bond at low yields, where the call price caps its price; a putable bond always has positive convexity and has a lower effective duration at high yields, where the put price floors its price.
- $\%\Delta PV^{Full} \approx -\text{EffDur} \times \Delta\text{Curve} + \frac{1}{2} \times \text{EffCon} \times (\Delta\text{Curve})^2$, and the convexity effect takes the sign of the convexity whatever the direction of the rate change.
- A key rate duration is the sensitivity of value to the benchmark yield at one maturity with all other yields held constant; key rate durations sum to effective duration and measure shaping risk from nonparallel shifts.
- Analytical durations assume that credit spreads do not change when benchmark yields move, while empirical duration is estimated from historical prices; in a flight to quality a corporate bond portfolio's empirical duration is lower than its analytical duration, and for government bonds the two should be similar.

EXAM SHORTCUTS

- For a portfolio of zero-coupon bonds with annual compounding, each key rate duration is the zero's portfolio weight times its maturity divided by one plus its yield, as in the 2-year and 7-year example, so no repricing is needed.

FORMULAS

Why effective duration and effective convexity for bonds with embedded options	$\text{effective duration (EffDur)} = \dfrac{V_- - V_+}{2V_0\,\Delta\text{Curve}}$ $\text{effective convexity (EffCon)} = \dfrac{V_- + V_+ - 2V_0}{(\Delta\text{Curve})^2\,V_0}$
Percentage price change for a change in the benchmark yield	$\%\Delta PV^{Full} \approx -\text{EffDur} \times \Delta\text{Curve} + \frac{1}{2} \times \text{EffCon} \times (\Delta\text{Curve})^2$
Key rate duration and shaping risk	$\%\Delta V \approx -\sum_k \text{KeyRateDur}_k \times \Delta r_k$

64 Credit Risk

- Bottom-up credit analysis looks at the borrower's capacity, capital, collateral, covenants and character, and top-down analysis looks at conditions, country and currency.
- $\text{Expected loss} = \text{PD} \times \text{LGD}$, where in money terms $\text{LGD} = \text{expected exposure} \times (1 - \text{recovery rate})$ and the loss severity is $1 - \text{recovery rate}$.
- Exam convention: loss given default is often given as a rate (LGD%) and multiplied directly by the probability of default to give expected loss as a percentage; current practice states LGD as a money amount or as a percentage of exposure at default, the percentage form being the loss severity.

- The expected loss rate, $\text{PD} \times (1 - \text{recovery rate})$, estimates the fair credit spread; an actual spread above it means investors are more than fairly compensated, and one below it means they are under-compensated.
- Ratings from AAA/Aaa down to BBB−/Baa3 are investment grade and ratings of BB+/Ba1 and below are non-investment grade (high-yield).
- Credit ratings lag market prices, struggle with risks such as litigation, natural disasters and debt-financed buybacks, and can be wrong, so ratings are no substitute for an investor's own due diligence.
- Spreads narrow when growth and profits are strong and widen in a recession; in a contraction credit curves rise and flatten, and in an expansion they fall and steepen.
- $\%\Delta P_{\text{full}} \approx -\text{ModDur} \times \Delta\text{Spread} + \frac{1}{2}\,\text{Convexity} \times (\Delta\text{Spread})^2$, and the liquidity spread inside a yield spread equals the yield at the bid price less the yield at the offer price.

EXAM SHORTCUTS

- Bid and offer yields come from the same TVM entries with only PV changed, so the second yield needs one new entry and one compute.
- For an option-free bond, with the benchmark yield and all other factors unchanged, back out a spread change from a price change by starting from $-\%\Delta P/\text{ModDur}$; for a price fall the true widening is slightly larger than this, and for a price gain the true narrowing is slightly smaller.

FORMULAS

Measuring credit risk	$\text{expected loss} = \text{probability of default} \times \text{loss given default}$ $\text{LGD (in money)} = \text{expected exposure} \times (1 - \text{recovery rate})$ $\text{LGD\% (rate)} = \text{loss severity} = 1 - \text{recovery rate}$ $\text{credit spread} \approx \text{PD} \times \text{LGD\%} = \text{PD} \times (1 - \text{recovery rate})$
Market factors: liquidity	$\%\Delta P_{\text{full}} \approx -\text{ModDur} \times \Delta\text{Spread} + \frac{1}{2}\,\text{Convexity} \times (\Delta\text{Spread})^2$

65 Credit Analysis for Government Issuers

- A national government services its debt mainly through its power to tax, so sovereign credit analysis asks whether the country has the conditions for stable growth with low inflation.
- The five qualitative factors of sovereign credit are institutions and policy (including the government's willingness to pay, given sovereign immunity), fiscal flexibility, monetary effectiveness, economic flexibility and external status.
- The three quantitative factors are fiscal strength (a low debt burden and good debt affordability), economic growth and stability, and external stability (high FX reserves relative to GDP and to external debt, and low external debt relative to GDP).
- A higher debt/GDP or interest/revenue ratio means weaker fiscal strength, and debt burden and debt affordability can point in different directions for the same country.
- A country with a reserve currency can more easily issue debt to foreign investors in its own currency and can maintain larger budget deficits and debt.
- Agencies and government sector banks carry implied government support and ratings close to the sovereign's, while supranational ratings depend on the implicit support of the sponsoring governments and institutions.
- General obligation bonds are unsecured and backed by the issuing government's taxing power, while revenue bonds are serviced only from one project's revenues and often carry more credit risk.
- Regional governments cannot print money and usually must balance their operating budgets, and revenue bonds are analyzed like corporate bonds, with a higher debt-service coverage ratio (project revenue net of operating costs, divided by the interest and principal due) meaning a safer bond.

66 Credit Analysis for Corporate Issuers

- The qualitative factors in corporate credit analysis are the business model, industry competition, business risk and corporate governance, the last judged through covenants and accounting policies.
- All else equal, credit quality is higher with strong operating profits and recurring revenues, low leverage, high coverage of debt service by income and high liquidity for short-term obligations.
- EBITDA is operating income plus depreciation and amortization, FFO starts from net income from continuing operations and adds back noncash items, and RCF is the chosen operating cash flow measure minus dividends.
- Higher EBIT margin, EBIT/interest expense and RCF/net debt indicate higher credit quality, while for debt/EBITDA a lower value indicates higher credit quality; net debt is debt minus cash and marketable securities.
- The priority of claims runs first lien, senior secured (second lien), junior secured, senior unsecured, senior subordinated, subordinated, junior subordinated; debt in the same category ranks pari passu, and any secured claim not covered by collateral ranks with senior unsecured claims.
- Recovery rates fall and credit risk rises with each step down in seniority, although in practice strict priority is often not applied because a negotiated settlement shortens a costly bankruptcy.
- The issuer credit rating (corporate family rating) is typically based on senior unsecured debt, and issue ratings are notched above or below it according to seniority and covenants, with notching more common for lower-rated issuers.
- Under structural subordination, a subsidiary's own bonds have the first claim on its cash flows, so the parent's bonds are effectively subordinated to them for those cash flows even though they are not formally junior.

67 Fixed-Income Securitization

- In a securitization, an originator sells a pool of loans or receivables, the collateral, to a special purpose entity, which issues asset-backed securities paid from the borrowers' loan repayments.
- Securitization lets originators increase business activity, earn fees, hold lower capital reserves and turn illiquid loan portfolios into cash.
- Investors gain risk and return tailored to their needs, access to loan pools without the expertise to originate and service loans, and securities that are easier to sell than the underlying loans.
- For economies and financial markets, securitization decreases liquidity risk, improves market efficiency and gives originators lower financing costs and lower leverage.
- ABS investors bear uncertainty in the timing and size of cash flows, for example from unexpected prepayments, and the credit risk of the collateral passes through to them.
- The seller (depositor) originates and sells the loans, the SPE (issuer or trust) buys them and issues the ABS, the servicer collects from borrowers, and the trustee safeguards the collateral and cash flows for ABS holders.
- The SPE owns the collateral outright as a legally separate entity, which makes it bankruptcy remote: the seller's creditors cannot reach the pool, and ABS holders have no claim on the seller's other assets.
- Collections from the pool pay the servicing fee and other administrative fees first, so ABS investors receive less than the total payments collected.

68 Asset-Backed Security (ABS) Instrument and Market Features

- Covered bonds are senior debt of financial institutions backed by a segregated cover pool, usually mortgages, that stays on the issuer's balance sheet because no SPE is created.
- Covered bond investors have dual recourse to the cover pool and to the issuer's unencumbered assets, the cover pool is dynamic, and covered bonds generally yield less than comparable ABS.
- When an issuer misses a payment, a hard-bullet covered bond defaults at once and payments are accelerated, a soft-bullet one lets the maturity slip by up to a year, and a conditional pass-through one becomes a pass-through security at maturity if payments are still owed.

- Internal credit enhancements are overcollateralization, excess spread and subordination, under which junior tranches absorb losses first, up to their principal, to protect the senior tranches.
- Credit tranching redistributes default risk, while time tranching redistributes prepayment risk.
- Credit card ABS are backed by nonamortizing receivables; during the lockout (revolving) period investors receive only interest and fees, and principal repaid by cardholders buys new receivables.
- Solar ABS are backed by loans to homeowners to install solar energy systems, and many deals have a pre-funding period in which the trust adds new solar loans to the pool.
- A CDO differs from ordinary ABS by having a collateral manager who actively buys and sells securities in the pool, and the CLO, backed by leveraged loans, is now its most common form.

EXAM SHORTCUTS

- Under subordination, the senior tranche loses nothing until collateral losses exceed the total of the tranches ranked below it, so smaller losses need only be allocated among the junior tranches.

69 Mortgage-Backed Security (MBS) Instrument and Market Features

- Contraction risk is the risk that prepayments run faster than expected, typically when rates fall, which shortens the average life and forces reinvestment at lower rates; extension risk is the risk that they run slower, typically when rates rise, which lengthens it.
- Time tranching reallocates prepayment risk among bond classes without removing it, and the tranches that mature first give more protection against extension risk.
- A lower loan-to-value ratio and a lower debt-to-income ratio mean lower default risk, and a borrower with an underwater nonrecourse loan has a stronger incentive to default strategically.
- A GSE is legally separate from the government, so agency RMBS it guarantees carry only the GSE's own guarantee, while non-agency RMBS rely on credit enhancement.
- A pass-through's net coupon is below the pool's weighted average coupon because servicing and guarantee or insurance fees are deducted, and the WAC and WAM weight each mortgage by its share of the outstanding balance.
- A PAC tranche makes its scheduled payments as long as prepayments stay within a range, which reduces both contraction and extension risk, while the support tranche absorbs the variation and bears high prepayment risk.
- A principal-only security benefits from falling rates and faster prepayments, while an interest-only security is hurt by them.
- Commercial mortgages are nonrecourse, so CMBS analysis focuses on the property: a higher $\text{DSCR} = \text{NOI}/\text{debt service}$ and a lower LTV indicate better credit quality, call protection is common, and balloon risk is a form of extension risk.

FORMULAS

Mortgage pass-throughs and CMOs	$\text{WAC} = \sum_i w_i \times \text{mortgage rate}_i$
	$\text{WAM} = \sum_i w_i \times \text{remaining term}_i$
	$\text{pass-through rate} = \text{WAC} - \text{fees}$
Commercial mortgage-backed securities	$\text{DSCR} = \dfrac{\text{net operating income}}{\text{debt service}}$
	$\text{LTV} = \dfrac{\text{loan amount}}{\text{appraised value}}$

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