


Bond price




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Pricing bonds with forward rates

➤ Forward rates can be used to value a bond in the same manner as spot rates because they are interconnected.

• Discount bond cash flows one period by one period with forward rates.

Bond price



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Example:

➤ Suppose an analyst needs to value a four-year, 3.75% annual coupon payment bond, and he find the following forward rates: 0y1y at 1.88%, 1y1y at 2.77%, 2y1y at 3.54%, 3y1y at 4.12%. Calculate the bond price.

Price=

$$\frac{3.75}{1.0188} + \frac{3.75}{1.0188 \times 1.0277} + \frac{3.75}{1.0188 \times 1.0277 \times 1.0354} + \frac{103.75}{1.0188 \times 1.0277 \times 1.0354 \times 1.0412} = 102.637$$

Summary



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➤ Importance: ☆☆☆

➤ Content:

• Yield measures for fixed-rate bonds: compounded Vs. not compounded, street convention yield Vs. true yield, current yield Vs. simple yield, yield to (1st, 2nd ...) call, yield to worst.

• Yield measures for floating-rate bonds: quoted margin Vs. required margin.

Summary



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➤ Content (Cont.):

• Yield measures for money market instruments: discount rates Vs. add-on rates.

• Spot rates Vs. forward rates.

• Pricing bond with forward rates.

➤ Exam tips:

• 非常重要的考点，包括概念的辨析和计算。

• 常考点：Spot rates和forward rates的相互换算。

Yield Curve & Spread

Tasks:

- Define and compare the yield curves.
- Calculate and interpret spread measures for bonds.

Bond yield

Maturity structure of interest rates

- **Yield curve**: the relation between YTM and maturity.
- **Spot curve/zero curve**: a sequence of YTM on zero-coupon bonds.
- **Par curve**: a sequence of YTM such that each bond is priced at par value, and is obtained from a spot curve.
 - Formula: $Par = PMT/(1+Z_1) + \dots + (PMT + Par)/(1+Z_n)^n$
 - Par rate: PMT/Par
- **Forward curve**: a series of forward rates, each having the same tenor.

Bond price

Yield Spread

- The difference in yield between different bonds.
 - **Yield spread over benchmark**: difference in yield between bonds and benchmark rates.
 - ✓ The YTM can be separated to two components: the benchmark and the spread.
 - ✓ Generally, the benchmark capture the macroeconomic factors (e.g. GDP, CPI), and the spread capture the microeconomic factors (credit, liquidity, tax).

Bond yield

Yield Spread (Cont.)

- **G-spread**: yield spread over an actual or interpolated government bond.
- **I-spread**: yield spread of a specific bond over the standard swap rate in that currency of the same tenor.

Bond yield

Yield Spread (Cont.)

- **Zero volatility spread (Z-spread, static spread)**: a constant yield spread over a government spot curve.

$$PV = \frac{PMT}{(1 + z_1 + Z)^1} + \frac{PMT}{(1 + z_2 + Z)^2} + \dots + \frac{PMT + FV}{(1 + z_N + Z)^N}$$

- Implied assumption: the yield curve makes a parallel shift.



Bond yield

Yield Spread (Cont.)

- **Option-adjusted spread (OAS)**: yield spread that remove the influence of **embedded option**, generally subtract the option value from Z-spread.

- OAS = Z-spread - Option value (%);
- Callable bond: option value > 0, OAS < Z-spread;
- Puttable bond: option value < 0, OAS > Z-spread.



Summary

- **Importance:** ☆☆☆
- **Content:**
 - **Yield curves** (maturity structure): spot curve, par curve, forward curve.
 - **Spread measures:** G-spread, I-spread, Z-spread, OAS.
- **Exam tips:**
 - 主要概念的辨析。
 - 常考点: Z-spread和OAS的比较、适用场合。



Securitization & Mortgage

Tasks:

- **Describe** securitization process and the parties involved in.
- **Explain** benefits of securitization.
- **Describe** types and characteristics of mortgage loans.



Introduction of ABS

Asset-backed security (ABS)

- Securities backed, or collateralized, by a pool of assets.
 - **Securitized assets:** assets used to create ABS, including mortgage loans, automobile loans, and receivables.

Mortgage-backed security (MBS)

- By definition, is an asset-backed security, but often refers to securities backed by high-quality real estate mortgages.
 - The term "ABS" often refers to securities backed by other types of assets.



Securitization process

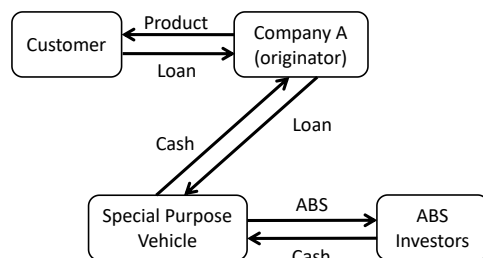
Securitization

- Move assets from the owner of the assets into a special purpose vehicle (SPV, SPE, SPC), then issue ABS backed by cash flows of the assets.
 - SPV buys the assets and issues ABS, and is a bankruptcy-remote vehicle.
 - SPV plays a pivotal role in the securitization process in terms of protecting the rights of creditors investing in ABS.



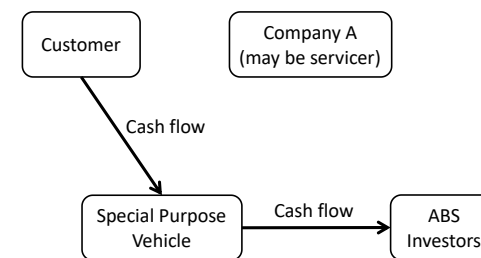
Securitization process

Example (during securitization):



Securitization process

Example (after securitization):



Benefits of securitization



Benefits of securitization

- Lower funding cost of borrowers while enhance the risk-adjusted return of investors (due to disintermediation).
- Increase the liquidity of financial asset.
- Allows investors to achieve better legal claims on the underlying.
- Allows investors to access asset classes matching their risk, return, and maturity profiles that are otherwise not directly available (tranching).

Mortgage loan



Mortgage loan

- Loan secured by the specified real estate property that obliges the borrower to make a predetermined series of payments to the lender.
 - **Foreclosure**: allow the lender to take possession of the mortgaged property and then sell it in order to recover funds if the borrower defaults.
 - **Loan-to-value ratio (LTV)**: ratio of the property's purchase price to the amount of the mortgage.
 - ✓ Lower LTV → more borrowers' equity → less likely to default → more protection for the lender.

Mortgage loan



Mortgage loan (Cont.)

- **Prepayment option**: entitle the borrower to prepay all or part of the outstanding mortgage principal prior to the scheduled due date that the principal must be repaid.
- **Prepayment penalty**: stipulate monetary penalty when a borrower prepays within a certain time period.
- **Prepayment risk**: the uncertainty that the cash flows will be different from the scheduled cash flows due to the borrowers' prepayment.

Mortgage loan



Mortgage loan (Cont.)

- **Recourse loan**: the lender has a claim against the borrower for the shortfall between the outstanding balance and the proceeds received from the sale of the property.
 - Less likely to default.
- **Non-recourse loan**: the lender cannot claim borrower's personal assets except for collateral property.
 - More likely to default.

Summary



- **Importance:** ☆☆
- **Content:**
 - ABS & MBS
 - Process of securitization and the parties involved in.
 - Benefits of securitization.
 - Mortgage: foreclosure, LTV, prepayment, recourse.
- **Exam tips:**
 - 主要了解概念。
 - 常考点：SPV的结构与特征。

Mortgage Pass-through Security

Tasks:

- **Describe** characteristics of mortgage pass-through security (MPS).
- **Explain** the cash flows and risks for MPS.
- **Describe** prepayment risk of MBS.

Residential MBS



Residential MBS (RMBS)

- RMBS are backed by a pool of residential mortgage loans.
 - **Agency RMBS:** guaranteed by a federal agency (Ginnie Mae) or by either of the two government-sponsored enterprises (GSE, i.e. Fannie Mae and Freddie Mac).
 - ✓ Ginnie Mae carry the full faith of U.S government.
 - ✓ The two GSEs do not carry the full faith of US government, but are considered with high credit quality.

Residential MBS



Residential MBS (Cont.)

- **Non-agency RMBS:** issued by private entities and are not guaranteed by a federal agency or a GSE.

Residential MBS



Conforming mortgage

- Loans that satisfy the underwriting standards for inclusion as collateral for an agency RMBS.
 - Maximum size of the loan;
 - Maximum loan-to-value ratio;
 - Loan documentation and insurance required.

Non-conforming mortgage

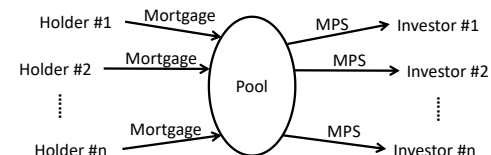
- Loans that fail to satisfy the underwriting standards.

Residential MBS



Mortgage pass-through security (MPS, 抵押转手债券)

- A security created when one or more holders of mortgages form a pool of mortgages and sell shares or participation certificates in the pool.



Residential MBS



Mortgage pass-through security (Cont.)

- **Weighted average coupon rate (WAC):** weighting the mortgage rate of each mortgage loan in the pool.
- **Pass-through rate (net interest, net coupon):** the coupon rate that investors receive.
 - Mortgage rate on the underlying pool less the service and insurance fee.
- **Weighted average maturity (WAM):** weighting the remaining number of months to maturity for each mortgage loan in the pool.

Residential MBS



Measurement of prepayment rate

- **Single monthly mortality (SMM) rate:** a monthly measure of prepayment rate.
 - $SMM = \text{Prepayment for month} / (\text{Beginning mortgage balance for month} - \text{Scheduled principal repayment for month})$

Residential MBS



Measurement of prepayment rate (Cont.)

- **Conditional prepayment rate (CPR)**: corresponding annualized rate of prepayment rate.
 - A CPR of 6% means that approximately 6% of the outstanding mortgage balance at the beginning of the year is expected to be prepaid by the end of the year.

Residential MBS



Measurement of prepayment rate (Cont.)

- **PSA prepayment benchmark**: a monthly series of CPRs by Public Security Association (PSA), assuming prepayment rates are low for newly originated mortgages and then speed up as the mortgages become seasoned.
 - The benchmark is said to be 100 PSA.
 - Slower or faster rates are referred to as some percentage of PSA.

Residential MBS



Weighted average life

- The convention-based average time to receipt of all principal repayments (scheduled principal repayments and projected prepayments).
 - Gives investors an indication of how long they can expect to hold the MBS before it is paid off.

Residential MBS



Prepayment risk

- **Contraction risk**: when interest rates decline, the security will have a shorter maturity because homeowners refinance at now-available lower interest rates.
 - Reinvest at lower interest rates;
 - Price appreciation is not as great as identical bond without prepayment option.

Residential MBS



Prepayment risk (Cont.)

- **Extension risk:** when interest rates rise, fewer prepayments will occur, and the security becomes longer maturity.

Summary



- **Importance:** ★★★
- **Content:**
 - Agency RMBS Vs. Non-agency RMBS.
 - MPS: WAC, WAM, pass-through rate.
 - Measurement of prepayment rate: SMM, CPR, PSA.
 - Prepayment risk: contraction risk Vs. extension risk.
- **Exam tips:**
 - 主要了解概念。
 - 常考点1: SMM、CPR、PSA的概念, 相互关系。
 - 常考点2: 两种prepayment risk的定义、差异。

CMO & Other ABS



Tasks:

- **Describe** characteristics of collateralized mortgage obligations (CMO).
- **Explain** the cash flows and risks for CMO.
- **Describe** characteristics and risks of commercial MBS, non-mortgage ABS, and CDO.

Residential MBS



Structuring

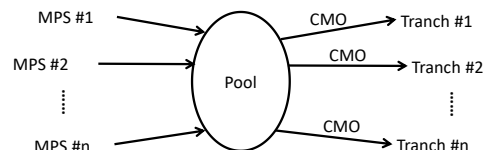
- Redistribute the risk of mortgage-related products to different bond classes or tranches.
 - **Time tranching:** redistribute the prepayment risk associated with the collateral.
 - **Credit tranching:** redistribute the credit risk
 - ✓ Also called subordination or senior/subordinated structure.
- “Structuring” can not eliminate risk but redistribute risk.

Residential MBS

Collateralized mortgage obligations (CMO, 担保抵押债券)

- Securities that redistribute the cash flows of mortgage-related products to various tranches.

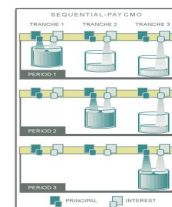
- Backed by mortgage pass-through security (MPS)



Residential MBS

Collateralized mortgage obligations (Cont.)

- **Sequential-pay tranches:** each class of bond (the tranches) would be retired sequentially.



- Tranche 1 is protected against extension risk, but face more contraction risk.
- Tranche 3 is protected against contraction risk, but face more extension risk.



Residential MBS

Collateralized mortgage obligations (Cont.)

- **Planned amortization class (PAC) tranches** offer greater predictability of the cash flows as long as the prepayment rate is within a specified band (collar)
 - Have limited (but not complete) protection against both extension risk and contraction risk
- **Support tranches/companion tranches** absorb the prepayment risk first, and expose investors to greater prepayment risk



Residential MBS

Collateralized mortgage obligations (Cont.)

- **Floating-rate tranches** are constructed by a floater and an inverse floater combination from any of the fixed-rate tranches in a CMO structure.



Residential MBS



Non-agency RMBS

- In order to obtain a favorable credit rating, non-agency RMBS often require one or more credit enhancements.
- **Internal credit enhancements**
 - ✓ Senior/subordinated structures;
 - ✓ Reserve funds: cash reserve or excess spread account;
 - ✓ Overcollateralization.
- **External Credit Enhancements**
 - ✓ Financial guarantee by a third party (e.g. monoline insurance companies).

Commercial MBS



Commercial mortgage-backed securities (CMBS)

- Are backed by a pool of commercial mortgage loans on income producing property.
- Commercial mortgage loans are typically non-recourse loans, and the lender will face credit risk.
- Measures of credit quality:
 - ✓ Loan-to-value ratio, the lower the better;
 - ✓ Debt service coverage (DSC) ratio: net operating income (NOI)/debt service, the higher the better.

Commercial MBS



Commercial MBS (Cont.)

- CMBS investors have considerable call protection, which differs from RMBS and results in CMBS trading more like corporate bond.
- CMBS investors may face “balloon risk” because many commercial mortgages are balloon loans.
 - The borrower may not be able to make the balloon payment due to failure to refinance or sell the property to generate sufficient funds.

Non-mortgage ABS



Auto Loan Receivable-backed Securities

- Backed by auto loan and lease receivables.
- The cash flows consist of regularly scheduled monthly loan payments (interest payment and scheduled principal repayments) and any prepayments.
- All have some form of credit enhancement, often a senior/subordinated structure.

Non-mortgage ABS



Credit card receivable-backed securities

- Backed by credit card receivables.
- The cash flows consist of finance charges collected, fees, and principal repayments.
 - Interest is paid to security holders periodically, and typically uncapped for floaters;
 - Are non-amortizing loans with lockout period, during which the principal is reinvested and only finance charges collected and fees is paid to investors.

Collateralized debt obligations



Collateralized debt obligation (CDO, 担保债务凭证)

- A generic term to describe a security backed by a diversified pool of one or more debt obligations.
- Requires a collateral manager to buy and sell debt obligations for and from the CDO portfolio of assets to generate sufficient cash flows.
- Structure of a CDO includes senior, mezzanine, and subordinated/equity bond classes.

Summary




- **Importance:** ★★
- **Content:**
 - Structuring: time tranching & credit tranching
 - CMO: sequential-pay tranches, PAC & support tranche.
 - Non-agency RMBS and CMBS.
 - Non-mortgage ABS and CDO.
- **Exam tips:**
 - 主要掌握概念。
 - 常考点: Tranching的不同方式, 及各自的风险特征。


Sources of Return from Bond Investment



Tasks:


- **Calculate and interpret** the sources of return from investing in a fixed-rate bond.


Sources of return




Sources of return from investing in a fixed-rate bond

- Promised coupon and principal payments.
- Reinvestment of coupon payments.
- Capital gain or loss on the sale of bond prior to maturity.
 - Capital gains/losses arise if a bond is sold at a price above/below its constant-yield price trajectory.
 - **Carrying value:** the price on the constant-yield price trajectory at that time, is the purchase price plus/minus the amortized amount of the discount/premium.





Sources of return




Interest rate risk on fixed-rate bond investment (Cont.)

- The risk that interest will change which affects the reinvestment of coupon payment and the market price if the bond is sold prior to maturity.
 - **Coupon reinvestment risk:** uncertainty about income from reinvesting coupon payments.
 - ✓ Increase/decrease when interest rates go up/down.
 - **Market price risk:** uncertainty about bond price.
 - ✓ Decrease/increase when interest rates go up/down.





Sources of return




Interest rate risk vs. investment horizon


- Two investors holding the same bond (or bond portfolio) can have different exposures to interest rate risk if they have different investment horizons.
 - Market price risk matters more when the investor has a short-term investment horizon.
 - ✓ Horizon yield is negatively related with interest rates.
 - Coupon reinvestment risk matters more when the investor has a long-term investment horizon.
 - ✓ Horizon yield is positively related with interest rates.



Summary



- **Importance:** ☆☆
- **Content:**
 - Sources of return: coupon and principal, coupon reinvestment income, capital gain/loss.
 - Interest rate risk: reinvestment risk Vs. market price risk.
 - Interest rate risk Vs. investment horizon.
- **Exam tips:**
 - 主要掌握概念，了解不同投资期限下 Interest rate risk 的主要表现方式。



Types of Duration

Tasks:

- Define, calculate, and interpret Macaulay, modified, and effective durations.
- Calculate and interpret the money duration of a bond and price value of a basis point (PVBP).

Duration

Duration

- The sensitivity of bond's full price to changes in the bond's YTM or in benchmark interest rates.
 - Assuming that variables other than YTM or benchmark rates are held constant.
 - Measures the **instantaneous** change in bond price when YTM or benchmark rates change.

Duration

Duration

- **Yield duration:** sensitivity of bond price to the bond's own YTM.
 - Macaulay duration , modified duration, money duration, price value of a basis point (PVBP).
- **Curve duration:** sensitivity of bond price to a benchmark yield curve.
 - In practice, the government par curve is often used.
 - Effective duration is a curve duration statistic.

Duration

Yield duration

- **Macaulay duration:** weighted average time to receipt of the bond's promised payments, where the weights are the shares of the full price that correspond to each of the bond's promised future payments.

$$\text{MacDur} = \frac{\sum_{t=1}^n t \times \text{PVCF}_t}{\sum \text{PVCF}_t}$$

- MacDur is measured in terms of time periods.
- For perpetuity bond, $\text{MacDur} = (1+r)/r$.

Duration



Yield duration

- **Modified duration**: requires a simple adjustment to Macaulay duration.

$$\text{ModDur} = \frac{\text{MacDur}}{1 + r}$$
 - r: yield per **period**.
- ModDur provides an **linear** estimate of the percentage price change for a bond given a change in its YTM.

$$\% \Delta \text{Price} \approx -\text{ModDur} \times \Delta \text{Yield}$$

Duration



Example:

- If the annual yield on a 6% semiannual coupon payment bond that matures on 14 February 2022 jumps by 100 bps, from 6.00% to 7.00%, and the bond's modified duration is 6.12, what should be the bond's percentage price change?
- **Answer:**

$$\% \Delta P = -6.12 \times 0.01 = -0.0612 = -6.12\%$$

Duration



Yield duration

- **Approximate modified duration**: an alternative approach to calculate modified duration.

$$\text{ApproxModDur} = \frac{P_- - P_+}{2 \times (\Delta \text{Yield}) \times P_0}$$
- **Approximate Macaulay duration**

$$\text{ApproxMacDur} = -\text{ApproxModDur} \times (1 + r)$$

Duration



Yield duration

- **Money duration/dollar duration**: a measure of the price change **in units of currency** given a change in its YTM.
 - MoneyDur = ModDur x Price (full)
 - ✓ MoneyDur per 100 units of par value = ModDur x Price (full) of bond per 100 of par value

Duration



Yield duration

➤ $\Delta P^{\text{Full}} = \text{MoneyDur} \times \Delta \text{Yield}$

- **Price value of a basis point (PVBP, DV01):** the money change in full price of a bond when its YTM changes by one basis point (0.01%).

$$\text{PVBP} = \frac{P_- - P_+}{2}$$

- ✓ P_- and P_+ are the full prices calculated by decreasing and increasing the YTM by 1 basis point.

Duration



Example:

- Suppose a 10-year, 8% annual-pay straight bond priced at 105. Calculate the PVBP if it has a par value of 10,000.
 - Step 1: $N=10$, $PV=105$, $PMT=8$, $FV=100$; CPT: $I/Y=7.28$
 - Step 2: calculate bond price with YTM of 7.27 and 7.29
 - ✓ $N=10$, $PMT=800$, $FV=10,000$, $I/Y=7.27$, CPT: $PV=10506.3$
 - ✓ $N=10$, $PMT=800$, $FV=10,000$, $I/Y=7.29$, CPT: $PV=10492.1$
 - Step 3: $\text{PVBP}=(10506.3-10492.1)/2=7.1$

Duration



Curve duration

- **Effective duration:** the sensitivity of bond's price to a change in a benchmark yield curve.

$$\text{EffDur} = \frac{P_- - P_+}{2 \times (\Delta \text{Curve}) \times P_0}$$

- Measures interest rate risk in terms of a **parallel shift** in the benchmark yield curve (ΔCurve).
- Used for bonds with **embedded option due to uncertain future cash flow and absence of well-defined IRR (YTM)**.

Duration



Example:

- Suppose a callable bond is priced at 101.060489, and when the government par curve is raised and lowered by 25 bps, the new full prices for the callable bond are 99.05012 and 102.890738, respectively. Calculate the effective duration of the callable bond.
- **Answer:**
Effective duration = $(102.890738 - 99.05012) / (2 \times 0.0025 \times 101.060489) = 7.6006$

Duration

Key rate duration/partial duration

- A measure of a bond's sensitivity to a change in the benchmark yield curve at a specific maturity segment.
 - Useful to identify "shaping risk" for a bond (e.g., the yield curve becoming steeper or flatter).
 - Useful to measure bond's sensitivity to nonparallel shift of the benchmark yield curve.



Summary

- Importance: ☆☆☆
- Content:
 - Next page.
- Exam tips:
 - Fixed Income 中最重要的知识点，概念、辨析、计算都可考。
 - 常考点1：几种duration的差异辨析、适用性；
 - 常考点2：effective duration、PVBP的计算。



Summary

Summary of duration types:

- Yield duration (price sensitivity to YTM)
 - Uncertain future cash flow
 - No well-defined IRR (YTM)
 - Macaulay duration
 - Modified duration
 - Money duration
 - ✓ PVBP (DV01)
- Curve duration (price sensitivity to benchmark yield curve)
 - Non-parallel shift
 - Effective duration
- Key rate duration (sensitivity to yield at specific maturity)



Duration Properties & Convexity

Tasks:

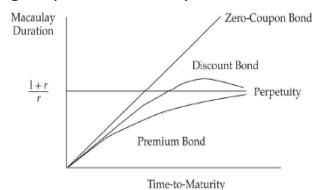
- Explain how a bond's maturity, coupon, embedded options, and yield level affect its interest rate risk.
- Calculate the duration of a portfolio and explain the limitations of portfolio duration.
- Calculate and interpret approximate convexity.



Duration

Properties of bond duration

- Longer time-to-maturity usually leads to higher duration.
- Higher coupon rate leads to lower duration.
- Higher yield-to-maturity leads to lower duration.

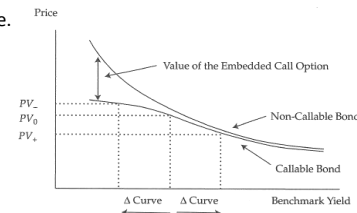


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Duration

Properties of bond duration (Cont.)

- Embedded **call** option leads to lower effective duration, especially when interest rates are **falling**, due to shorter expected life.

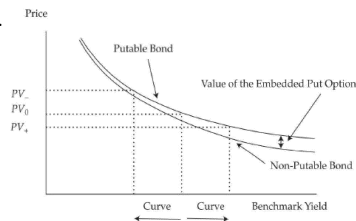


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Duration

Properties of bond duration (Cont.)

- Embedded **put** option leads to lower effective duration, especially when interest rates are **rising**, due to shorter expected life.



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Duration

Bond portfolio duration

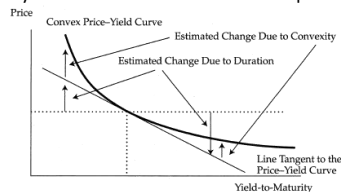
- Two methods to calculate the portfolio duration:
 - Method 1: the weighted average of time to receipt of the aggregate cash flow.
 - ✓ Theoretically correct but difficult to use in practice.
 - Method 2: the weighted average of the individual bond durations.
 - ✓ Portfolio duration = $w_1D_1 + w_2D_2 + \dots + w_nD_n$
 - ✓ Limitations: implicitly **assume a parallel shift** in the yield curve.

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Convexity

Convexity

- The “second-order” effect of the price-yield curve
 - The more curved the price-yield curve, the worse the only-duration-based estimate of the price change.



Convexity

Convexity

- The estimate of percentage change in bond's full price can be improved by adding convexity adjustment.

$$\% \Delta \text{Price}^{\text{Full}} \approx [-\text{ModDur} \times \Delta \text{Yield}] + \left[\frac{1}{2} \times \text{Con} \times (\Delta \text{Yield})^2 \right]$$

- The convexity adjustment is always positive when convexity is positive.

- **Approximate convexity:**

$$\text{ApproxCon} = \frac{P_1 + P_2 - 2P_0}{(\Delta \text{Yield})^2 \times P_0}$$



Convexity

Example:

- Suppose a bond with modified duration of 29.498 and convexity of 884.7, when its YTM is expected to fall by 10 bps, what should be the expected percentage price change?

- **Answer:**

$$\begin{aligned} \% \Delta \text{Price}^{\text{Full}} &\approx [-29.498 \times (-0.001)] + \left[\frac{1}{2} \times 884.7 \times (-0.001)^2 \right] \\ &= 2.994\% \end{aligned}$$



Convexity

Money convexity

- The second-order effect on the full price of a bond in units of currency given a change in the YTM.
 - $\text{MoneyCon} = \text{Convexity} \times \text{Price}^{\text{Full}}$
 - $\Delta P^{\text{Full}} = [-\text{MoneyDur} \times (\Delta \text{Yield})] + \left[\frac{1}{2} \times \text{MoneyCon} \times (\Delta \text{Yield})^2 \right]$



Convexity



Effective convexity

- Is a curve convexity statistic that measures the second-order effect of a change in a benchmark yield curve.

$$\text{EffCon} = \frac{P_{-1} + P_{+1} - 2P_0}{P_0 \times (\Delta \text{Curve})^2}$$

- Callable bonds often have negative convexity (concavity), especially when interest rates are low.
- Puttable bonds often have higher positive convexity, especially when interest rates are high.



Convexity



Benefits of greater convexity

- The more convex bond outperforms the less convex bond in both bull (rising price) and bear (falling price) markets.
 - For the same decrease in YTM, the more convex bond appreciates more in price;
 - For the same increase in YTM, the more convex bond depreciates less in price.

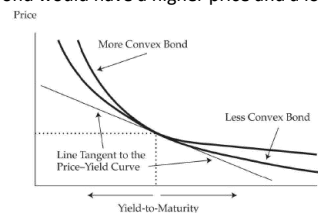


Convexity



Benefits of greater convexity (Cont.)

- If the positive attribute is priced in, the more convex bond would have a higher price and a lower YTM.




Convexity




Properties of bond convexity

- The factors that lead to greater convexity are the same as for duration.
 - longer time-to-maturity
 - lower coupon rate
 - lower yield-to-maturity
- For bonds with same duration, the one that has the greater dispersion of cash flows has the greater convexity.




Summary




➤ **Importance:** ☆☆☆

➤ **Content:**


- **Factors on duration:** time-to-maturity (\uparrow), coupon rate (\downarrow), YTM (\downarrow), option (\downarrow).
- Bond portfolio duration.
- **Convexity**, money convexity, effective convexity.


Summary



➤ **Exam tips:**

- Fixed Income 中最重要的知识点，概念、计算都可能考。
- 常考点1：影响 duration（interest rate risk）的因素和方向。
- 常考点2：Portfolio duration 的计算和 limitation。
- 常考点3：给出 duration、convexity 和 Δ yield，计算债券价格变化百分比。







Interest Rate Risk Vs. Investment Horizon

Tasks:

- **Describe** the relationship between interest rate risk and investment horizon.
- **Explain** how changes in credit spread and liquidity affect bond yield-to-maturity and price.

Interest rate risk Vs. Investment horizon



Term structure of yield volatility

- The relationship between the volatility of bond YTM and time-to-maturity.
- Longer term bond yields often tend to be less volatile, resulting in a downward-sloping term structure of yield volatility.

Interest rate risk Vs. Investment horizon



Term structure of yield volatility

- The bond price changes are products of two factors:
 - 1. the impact per basis-point change in the YTM (duration & convexity);
 - 2. the number of basis points in the YTM change (yield volatility).
- Shorter-term bond may have more price volatility than a longer-term bond because of higher yield volatility.



Interest rate risk Vs. Investment horizon



Macaulay duration

- The investment horizon for which coupon reinvestment risk and market price risk offset each other.
- Assumption: there is a one-time "parallel shift" in the yield curve that occurs before the next coupon payment date.

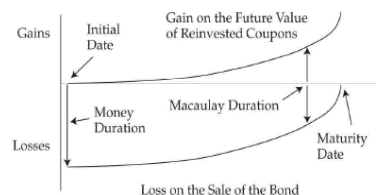


Interest rate risk Vs. Investment horizon



Macaulay duration (Cont.)

- When interest rates rise:

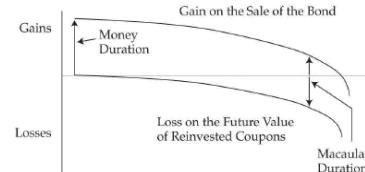


Interest rate risk Vs. Investment horizon



Macaulay duration (Cont.)

- When interest rates fall:



Interest rate risk Vs. Investment horizon



Macaulay duration (Cont.)

- When investment horizon > Macaulay duration:
 - Reinvestment risk dominates market price risk;
 - Investor's risk is to lower interest rates.
- When investment horizon = Macaulay duration:
 - Reinvestment risk offsets market price risk.
- When investment horizon < Macaulay duration:
 - Market price risk dominates reinvestment risk;
 - Investor's risk is to higher interest rates.

Interest rate risk Vs. Investment horizon



Duration gap

- Bond's Macaulay duration minus investment horizon.
 - When duration gap < 0, reinvestment risk dominates market price risk;
 - When duration gap = 0, reinvestment risk offsets market price risk;
 - When duration gap > 0, market price risk dominates reinvestment risk.

Credit and liquidity risk



Credit and liquidity spread

- The YTM on a corporate bond is composed of a government benchmark yield and a spread over that benchmark.
 - A change in the bond's YTM can originate in either component or a combination of the two.
- The same duration and convexity statistics apply for a change in the benchmark yield as for a change in the spread.

$$\% \Delta \text{Price}^{\text{Full}} \approx [-\text{ModDur} \times \Delta \text{Spread}] + \left[\frac{1}{2} \times \text{Con} \times \Delta \text{Spread}^2 \right]$$

Summary



- **Importance:** ☆☆
- **Content:**
 - Price volatility Vs. time-to-maturity.
 - Interest rate risk Vs. investment horizon.
 - Interpretation of Macaulay duration.
- **Exam tips:**
 - 主要掌握概念。
 - 常考点：不同 investment horizon 下的投资者的 interest rate risk exposure。

Credit Risk & Credit Rating

Tasks:

- **Describe** credit risk and credit-related risks affecting corporate bonds.
- **Describe** seniority rankings and potential violation.
- **Describe** credit rating, and **explain** risks in relying on ratings from credit rating agencies.

Credit and credit-related risk

Credit risk

- The risk of loss resulting from the borrower (issuer of debt) failing to make full and timely payments of interest and/or principal.
 - **Default risk/default probability**: the probability that a borrower default.
 - **Loss severity/loss given default**: the portion of a bond's value (including unpaid interest) an investor loses.
 - **Expected loss** = Default probability x Loss severity

Credit and credit-related risk

Credit risk

- **Recovery rate**: the percentage of the principal amount recovered in the event of default.
 - $\text{Loss severity} = 1 - \text{Recovery rate}$

Credit and credit-related risk

Credit-related risk

- **Spread risk**: the risk of yield premium to "default-risk free" bonds, such as U.S. Treasury bonds.
 - **Credit migration risk/downgrade risk**: bond issuer's creditworthiness deteriorates, or migrates lower, causing the yield spreads wider and the price lower.
 - **Market liquidity risk**: the price at which investors can actually transact-buying or selling-may differ from the price indicated in the market.

Seniority ranking

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Seniority ranking

Refers to the priority of payment, or priority of claims.

First Lien Loan

Senior Secured debt

Senior Unsecured debt

Junior Subordinated debt

Subordinated debt

Senior Subordinated debt

Seniority ranking

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Potential violation of seniority ranking

Priority of claims is not always absolute.

All impaired claimants get to vote to confirm the plan of reorganization.

There may be disputes in reorganization, and resolution of these disputes takes time and incurs expenses.

To avoid the time, expense, and uncertainty over disputed issues, the claimants have a strong incentive to negotiate and compromise.

Credit rating

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Credit rating

Three major credit rating agencies: Moody, S&P and Fitch.

	Moody	S&P	Fitch
Investment grade	Aaa	AAA	AAA
	Aa1	AA+	AA+

	Baa2	BBB	BBB
	Baa3	BBB-	BBB-
Non-investment Grade "Junk" or "High Yield"	Ba1	BB+	BB+

	Ca	CC	CC

Credit rating

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Notching

Rating agencies will typically provide both **issuer** and **issue ratings**, particularly as they relate to corporate debt.

Issuer rating: address an obligor's overall creditworthiness.

Issue rating: specific financial obligations of an issuer and take into consideration such factors as ranking in the capital structure (e.g., secured or subordinated).

Notching: credit ratings on issues can be moved up or down from the issuer rating.

Credit rating



Risks in relying on agency ratings

- Credit ratings can be very dynamic;
- Rating agencies are not infallible;
- Other types of so-called idiosyncratic or event risk are difficult to capture in ratings;
- Ratings tend to lag market pricing of credit.

Summary



- **Importance:** ☆
- **Content:**
 - Components of credit risk, credit-related risk.
 - Seniority ranking and potential violation.
 - Credit rating.
- **Exam tips:**
 - 了解基本概念即可。

Credit Analysis



Tasks:

- **Explain** the four Cs of traditional credit analysis.
- **Explain** special considerations when evaluating the credit of high yield, sovereign, and municipal debt issuers and issues.

Credit analysis



Traditional credit analysis: 4Cs analysis

- **Capacity:** ability of the borrower to make its debt payments on time;
- **Collateral:** the quality and value of the assets supporting the issuer's indebtedness;
- **Covenants:** the terms and conditions of lending agreements that the issuer must comply with;
- **Character:** the quality of management.

Credit analysis



Capacity analysis

- Industry structure - Porter's five forces model
- Industry fundamentals
- Company fundamentals
- Competitive position
- Track record/Operating history
- Management's strategy and execution
- Ratios and ratio analysis

Credit analysis



Capacity analysis (Cont.)

- Ratios and ratio analysis:
 - Profitability and cash flow (e.g. EBIT, EBITDA, FFO)
 - ✓ The higher, the better
 - Leverage (e.g. debt/capital, debt/EBITDA)
 - ✓ The lower, the better
 - Coverage (e.g. EBITDA/interest, EBIT /interest)
 - ✓ The higher, the better

Credit analysis



Collateral analysis

- Only when the default probability rises to a sufficient level do analysts typically consider asset or collateral value.
- The key point is to assess the asset value relative to the issuer's level (seniority ranking) of debt.
- Other factors to be considered:
 - Intangible assets
 - Amount of depreciation relative to capital expenditures
 - Equity market capitalization

Credit analysis



Covenants analysis

- Strong covenants protect bond investors, and weak covenants pose additional risks to bond investors.
 - Affirmative covenants: obligated to do something;
 - Negative covenants: limited in doing something.

Credit analysis



Character analysis

- Assessment of the soundness of management's strategy.
- Management's track record in executing past strategies, particularly if they led to bankruptcy or restructuring.
- Use of aggressive accounting policies and/or tax strategies.
- Any history of fraud or malfeasance: a major warning flag to credit analysts.
- Previous poor treatment of bondholders.



Yield spread



Yield spread

- Relative to a comparable, default-free bond, yield spread is composed of the credit spread and liquidity premium:
 - Yield spread = Credit spread + Liquidity premium



Yield spread



Yield spread

- Factors that influence the level of yield spread include:
 - Credit cycle
 - Broader economic conditions
 - Financial market performance overall, including equities
 - Broker-dealers' willingness to provide sufficient capital for market making
 - General market supply and demand




Yield spread



Yield spread

- Lower quality issuers typically experience greater spread volatility.
- Return impact from spread changes is driven by two main factors: modified duration and magnitude of spread change:
 - For small spread change:
Return impact $\approx -\text{ModDur} \times \Delta \text{Spread}$
 - For larger spread change:
Return impact $\approx [-\text{ModDur} \times \Delta \text{Spread}] + \left[\frac{1}{2} \times \text{Con} \times \Delta \text{Spread}^2 \right]$






Special consideration in credit analysis

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High yield debt

- The higher risk of default means more attention must be paid to recovery analysis (or loss severity), and is more in-depth with the following special considerations:
 - Greater focus on issuer liquidity and cash flow
 - Detailed financial projections
 - Detailed understanding and analysis of the debt structure
 - Understanding of an issuer's corporate structure
 - Covenants
 - Equity-like approach to high yield analysis




Special consideration in credit analysis

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Sovereign debt

- Two key issues for sovereign analysis are:
 - Government's ability to pay
 - Government's **willingness** to pay
- Credit of sovereign debt in its local currency is always at least as good that in foreign currency, due to the sovereign's ability to "print money" to repay debt within its own economy.




Special consideration in credit analysis

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Sovereign debt

- Important considerations in sovereign credit analysis:
 - Political and economic profile:
 - ✓ Institutional effectiveness and political risks
 - ✓ Economic structure and growth prospects
 - Flexibility and performance profile:
 - ✓ External liquidity and international investment position
 - ✓ Fiscal performance, flexibility, and debt burden
 - ✓ Monetary flexibility



Special consideration in credit analysis

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Municipal debt


- Usually can be classified as general obligation (GO) bonds and revenue bonds.
 - **GO bonds**: unsecured bonds issued with the full-faith and credit of the issuing government, and supported by the taxing authority of the issuer.
 - **Revenue bonds**: issued for specific project financing (e.g. toll roads, bridges, airports).
 - ✓ Higher risk than GO bonds because they are dependent on a single source of revenue.

Special consideration in credit analysis

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Municipal debt

- Credit analysis of GO bonds has some similarities to sovereign debt analysis, but have no ability to use monetary policy.




Special consideration in credit analysis

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Municipal debt (Cont.)

- Credit analysis of revenue bonds is a combination of project analysis and financial analysis around the project.
 - Project analysis: need, economic base, projected utilization.
 - Financial analysis: similar to corporate bond analysis.
 - ✓ Debt service coverage ratio (DSCR): a key credit metric, the higher the DSCR, the stronger the creditworthiness.



Summary

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- **Importance:** ★
- **Content:**
 - 4Cs analysis: capacity, collateral, covenants, character.
 - Spread analysis.
 - Special consideration: high-yield debt, sovereign debt, municipal debt.
- **Exam tips:**
 - 了解基本概念即可，常考4C的辨识。

