Overview and Learning Objectives

Overview

In this chapter, we learn how bondholders value their claims on the firm, i.e., the valuation of bonds, with the first principle of Finance, i.e. the Net Present Value rule discussed in Chapter 4A. We will apply the TVM formulas introduced in Chapter 4 here for the calculation of bond value and bond yield (YTM). This chapter also discusses fundamental concepts concerning the relationship between bond valuation, bond characteristics, and interest rates, as well as factors that determine bond prices.

Learning Objectives

After reading course materials on this chapter, students should be able to:

- Compute the values and yields of pure discount bonds and level coupon bonds.
- Explain the fundamental bond concepts concerning, and bond features that determine, how bond prices react to changes in interest rates.
- Explain the tax and risk characteristics of, and differences between, government bonds and corporate bonds.
- Explain and calculate the promised yield to maturity, expected return, and default premium of risky bonds.
- Interpret bond price quotes presented in the financial press.
- Explain the basic concepts concerning term structure of interest rates and yield curve.
- Explain the common determinants of bond yields.

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Bond Valuation and Concepts (Ref: Section 8.1)

A bond is a legally binding agreement that obligates the issuer/borrower to make specified payments to the holder/lender on specified dates. The specified payments include:

- the single principal amount (or par value, face value, maturity value), F, of the loan.
- a finite series of fixed coupon payments, C.

The timing of the principal repayment and the number of coupon payments are determined by the maturity of the bond, T.

An example of a bond:
Consider a U.S. government bond that has a coupon rate of 6 3/8% and matures in December 2009, listed on January 1, 2005.

- The Par Value of the bond, F, is $1,000.
- Coupon payments are made semi-annually (June 30 and December 31 for this particular bond).
  - Since the coupon rate is 6 3/8%, the annual coupon payment = coupon rate * par value = 6.375%*$1,000 = $63.75, and hence the semiannual coupon payment, C = $63.75 / 2 = $31.875.
- The Term to Maturity of the bond, T, is five years, implying 5*2 = 10 payments.

The intrinsic value of a bond is the present value, PV, of all its expected future cash flows over its life (T), discounted at its yield to maturity (YTM), r. Thus, the intrinsic value of a bond is the sum of the PV of a single cash flow, the par value (F), and the PV of an annuity, the coupon payments (C).

$$\textbf{Bond Value, } V = C*[1-1/(1+r)^T]/r + F/(1+r)^T$$

NOTE that the coupon rate is only used for determining the size of the coupon payment. The coupon rate should NEVER be used as the discount rate in determining the bond value! Instead, the yield to maturity (YTM) or the required rate of return is used as the appropriate discount rate in bond valuation!

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Basic Bond Features and TVM Notations

- **Intrinsic Value (V), PV:** If the bond is fairly priced in the market, the PV will be the market price (P) of a bond. In other words, the PV key can represent the intrinsic value or price of a bond.
- **Coupon (C), PMT:** The stated periodic fixed coupon payment of a bond. **NOTE** that the coupon rate is only used for determining the annual coupon payment of a bond. It is NOT the discount rate, and should NEVER be used as the discount rate in bond valuation!
- **Maturity (T), N:** The specified date on which the principal of a bond is due. It is used for determining the term to maturity, i.e., the number of periods remaining until the bond matures.
- **Face Value (F), FV:** It is also known as the par value and maturity value. Unless otherwise specified, its default value is $1,000.
- **Yield to Maturity (r), I/Y:** It is also known as the bond yield or the required return of a bond; YTM.
    - YTM is the appropriate discount rate, which equates the price of a bond with the present value of its future cash flows, used in determining the bond value.
    - **NOTE** that YTM is a total rate of return concept, which can be decomposed into the current yield, CY, and the capital gain yield, CGY, i.e., **YTM = CY + CGY**.
        - Current Yield, CY, is defined as annual coupon payment divided by bond price, i.e., **CY = Annual Coupon / Price**. It measures the portion of return on a bond that takes the form of current income.
        - Capital Gain Yield, CGY, measures the portion of return on a bond that takes the form of price appreciation. We can express **CGY = YTM – CY**.
    - To determine the intrinsic value of a bond, we use the YTM on similar bonds, in terms of default risk, as indicated by the bond rating, and term to maturity, as the appropriate discount rate in the intrinsic value calculation.

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Pure Discount Bonds

These bonds pay no periodic coupon payments, and hence they are also known as zero coupon bonds or "zeroes" or original issue discount bonds (OIDs). Their value can never be higher than their par value. Examples include Treasury Bills and Treasury STRIPs.

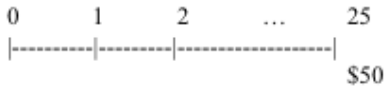
Information needed for valuing pure discount (or zero coupon) bonds includes:

- Time to maturity (T) = Maturity date − today's date
- Face (Par) value (F)
- Discount rate (r)

Value of a pure discount bond: $\mathbf{V = F \div (1 + r)^T}$

YTM of a pure discount bond: $\mathbf{r = (F/P)^{1/T} - 1}$

Example of Pure Discount Bond Valuation:
What is the price of a 25-year, pure discount bond that pays $50 at maturity if the current yield-to-maturity is 8 percent?



$V = 50 \div (1.08)^{25} =$ **$7.30**

Financial Calculator Approach

Inputs: N = 25; I/Y = 8; PMT = 0; FV = 50
Compute: PV = **-7.30**

Example of YTM or Bond Yield Calculation for Pure Discount Bonds:
Suppose a pure discount bond with a par value of $100 and maturing in two years, is selling at $84.17. What is the yield (YTM) on this bond?

$r = (\$100 \div \$84.17)^{1/2} - 1 =$ **9%**

Financial Calculator Approach

Inputs: N = 2; PV = -84.17; PMT = 0; FV = 100
Compute: I/Y = **9.00**

Level Coupon Bonds

Information needed to value level-coupon bonds:

- Coupon payment dates and Time to maturity (T)
- Coupon (C) per payment period and Face value (F)
- Discount rate (r)

Value of a Level-coupon bond:

$$\mathbf{V = F \div (1 + r)^T + (C/r) \times \{1 - 1 \div (1 + r)^T\}}$$

= PV of face value + PV of coupon payments annuity

Example of Level Coupon Bond Value Calculation
What is the value of a two-year $1000 par value bond paying 10% coupon semiannually if the required return is 8%, compounded semiannually?

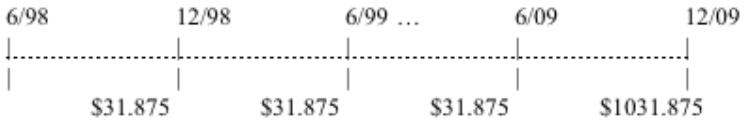
Coupon = $1000 × 0.1 / 2 = $50 every six month
$V = F/(1+r)^T + (C/r)x\{1 - 1/(1+r)^T\} = \$1000/(1.04)^4+(\$50/0.04)\times(1-1/1.04^4) = \$1,036.30$

Financial Calculator Approach

Inputs: N = 2*2 = 4; I/Y = 8/2 = 4; PMT = 50; FV = 1,000
Compute: PV = **-1,036**

Example of YTM or Bond Yield Calculation for Level Coupon Bonds
On July 1, 1998 a U.S. government bond is listed as 6 3/8s of December 2009 selling for 99.3125% of par value ($1000) in the Wall Street Journal.

The bondholder has a claim to the following cash flows:



This bond has a term of maturity of 11 1/2 years.
It is selling at 99.3125%*$1,000 = $993.125.
Its semiannual coupon payment is (6.375%*$1,000)/2 = $31.875.

Financial Calculator Approach

Inputs: N = 2*11.5 = 23; PV = -993.125; PMT = 31.875;
FV = 1,000
Compute: I/Y = 3.23 (Note that this is for 6-month only)
→ YTM = 3.23%*2 = **6.46%**

Please reference lecture slides for additional numerical illustrations on bond valuation, bond yield (YTM), current yield (CY) and capital gain yield (CGY)!

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Bond Concepts (Ref: Section 8.1)

- **Bond prices and interest rates (or bond yields) move in opposite direction.**
  - From Chapter 4, we learn that the higher the discount rate, the lower the present value.
- Classifying bonds by comparing their prices and their par values (Slide).
  - **Par bond:** A bond that sells at its par value; when the coupon rate is equal to the prevailing interest rate.
    - No capital gain or loss if held until maturity, i.e., CGY = 0.
    - Coupon rate = Current yield = Yield to maturity.
    - In general, issuers set the coupon rate on the new bond issue at the prevailing interest rate (yield) such that the new issue is sold at par.
  - **Discount bond:** A bond that sells below its par value; when the coupon rate is lower than the prevailing interest rate.
    - Capital gain resulted if held till maturity, i.e., CGY > 0.
    - Coupon rate < Current yield < Yield to maturity.
  - **Premium bond:** A bond that sells above its par value; when the coupon rate is higher than the prevailing interest rate.
    - Capital loss resulted if held till maturity, i.e., CGY < 0.
    - Coupon rate > Current yield > Yield to maturity.
- **A bond with longer maturity has higher relative (percentage) price change than one with shorter maturity when interest rate (YTM) changes, all other features being identical** (Slide).
- **A lower coupon bond has a higher relative price change than a higher coupon bond when interest rate (YTM) changes, all other features being identical** (Slide).

Interest Rate Risk

Interest rate risk is the fundamental type of risk for fixed income securities such as bonds. It describes the uncertainty on the return of a bond investment due to uncertainty in the future movements in interest rates. There are two forms of interest rate risk -

Price Risk - It refers to the fluctuation in bond prices due to changes in interest rates. Other factors being equal, (i) long-term bonds have MORE price risk than short-term bonds; and (ii) low coupon bonds have MORE price risk than high coupon bonds.

- NOTE that this type of interest rate risk is discussed above!

Reinvestment Risk - It refers to the uncertainty concerning the rates at which interim cash flows can be reinvested. Other factors being equal, (i) long-term bonds have LESS reinvestment risk than short-term bonds; and (ii) low coupon bonds have LESS reinvestment risk than high coupon bonds.

- NOTE that the association of reinvestment risk to bond features works in the opposite direction to that of the price risk!

Government and Corporate Bonds (Ref. Section 8.2)

Government Bonds

Long-term debt instruments issued by a governmental entity. **Treasury** bonds are bonds issued by the federal government; and **Municipal (or "munis")** bonds are those issued by a state or local government. Treasuries are considered to be default risk-free, but "munis" are subject to default risk just like corporate bonds. In the U.S., interest income from Treasuries are exempt from state income taxation, and interest income from "munis" are exempt from federal income taxation (and the taxation of the issuing state). Hence, "munis" are also known as the tax-exempt bonds.

When compare the yield on a tax-exempt bond to that on a taxable bond (such as corporate bonds) of comparable risk, the following measures can be considered –

- After-tax yield of taxable bond = (1 – t) * taxable bond yield, where t is the marginal tax rate of the investor under concerned. Note that for tax-exempt bonds, the applicable marginal tax rate is zero! (Slide)
- Equivalent taxable yield of tax-exempt bond = tax-exempt bond yield / (1 – t).

For example, the yield on a taxable bond is 10%, and that on a tax-exempt bond is 8%. Assume that both bonds have comparable risk level. For Investor A who has a marginal tax rate of 28%, the after-tax yield of the taxable bond would be 10%* (1-0.28) = 7.2%, which is less attractive than the tax-exempt bond that offers an after-tax yield of 8%. For Investor B who has a marginal tax rate of 15%, the equivalent taxable yield of the tax-exempt bond would be 8%/ (1-0.15) = 9.41%, which is less than the before-tax yield of 10% offered by the taxable bond. Hence, Investor A, who has a high marginal tax rate, would choose the tax-exempt bond, while Investor B, who has a low marginal tax rate, would choose the taxable bond!

Corporate Bonds and Bond Rating

Corporate bonds, which are issued by companies, present greater default risk relative to government bonds, thus there is an underlying difference between the bond's promised yield (i.e., yield to maturity) and its expected return. The calculation of the promised yield does not take into account the probability of default of the promised (coupon and principal) payments, while the expected yield does. Hence, the expected return of a risky bond tends to be lower than its promised yield, and the difference between the two yields increases with the probability of default, i.e., default risk, of the bond.

For example, consider a 5-year, 10% coupon corporate bond, which has a 20% probability to default on all its payments, is priced at $850. Its promised yield, i.e., YTM, would be –

- N = 5; PV = -850; PMT = 100; FV = 1000 → I/Y = 14.41% (= YTM)

However, its expected return would be –

- N = 5; PV = -850; PMT = 100*0.8 = 80; FV = 1000*0.8 = 800 → I/Y = 8.42% (= expected return)

Now, let us also consider a 5-year Treasury with the same coupon rate, but is priced at par, implying that the YTM on this risk-free bond is 10%. The difference of 4.41% (i.e., 14.41% - 10%) in the promised yields of this Treasury bond and the above risky corporate bond represents the default premium on the risky corporate bond!

Given the importance of understanding the risk of default, bond ratings play a key role in the pricing and analysis of corporate debt. From the perspective of bond rating, there are two general categories of (default) risky bonds – investment grade (high and medium credit quality) bonds Slide versus speculative grade (low and very low credit quality) bonds Slide. It is crucial for companies to attain an investment grade rating for their bonds because this allows them access to the bond market.

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Bond Markets (Ref. Section 8.3)

Most bond market transactions are conducted over-the-counter (OTC) among institutional investors and traders in large amounts. As such, their transactions are usually not transparent. The only exceptions are those involved Treasury securities. While daily bond trading volume (by dollar value) exceeds stock trading volume in aggregate due to the much higher number of bond issues, but trading in individual bond issues tends to be very thin.

Reading bond quotation from the Wall Street Journal

The financial press quotes **bond prices** as a **percentage of the par value**. In addition, federal government bonds are quoted in 32nds and corporate bonds are quoted in 8ths.

Example of U.S. Treasury Bond

Rate	Maturity	Bid	Asked	Chg.	Ask Yld.
6 3/8	Dec 09	99:09	99:10	+7	6.43

If you buy this government bond, the asked price is

> 99% + 10% / 32 = 99.3125% of par value.

Example of U.S. Corporate Bond

Bonds	Cur. Yld.	Vol	Close	Net Chg.
ChryF 13 1/4 99	11.8	5	112 1/8	-7/8

If you buy this Chrysler bond, the asked price is 112.125% of par value.

Clean versus Dirty Bond Prices

Buyers are expected to pay the sellers their shares of accrued interest on the bond's next coupon payment at the time of the transaction. In other words, buyers pay the full (or invoice) price, i.e., "DIRTY" price, not just the flat (or quoted) price, i.e., "CLEAN" price, to the sellers for the transaction.

Full (Invoice) price = quoted (flat) price + accrued interest

- where accrued interest is the seller's portion of the next coupon payment.
- accrued interest = coupon payment*(number of days since the last coupon payment)/(number of days between the last coupon payment and the next coupon payment)
- For Treasuries, actual calendar days are used in the counting; For corporate bonds, the convention of 30-day month and 360-day year is used in the counting.

Please reference the text for details on bond price reporting, and this numerical illustration for the calculations of clean versus dirty prices Slide Slide.

> Example: Suppose the last coupon was paid 50 days ago and there are 182 days in the current coupon period. If the semiannual coupon payment is $40, then the accrued interest would be (50/182) *40 = $10.99, and this would be added to the quoted price to determine the "dirty price."

Inflation and Interest Rates (Ref. Section 8.4)

Real versus Nominal Rates and Fisher Effect

Here is a quick review of what we have learned from Chapter 6 -

- Nominal rates (R) are rates that incorporate the inflation;
- Real rates (r) are the rates of change in purchasing power, i.e., the rate of change in the amount of resources.

We can express the relation between nominal rate and real rate as -

- **(1 + R) = (1 + r)(1 + h)** where h being the expected inflation rate. And a reasonable approximation, when expected inflation is relatively low, is R = r + h. (Slide)

A definition whereby the real rate can be found by deflating the nominal rate by the inflation rate: **r = [(1 + R) / (1 + h)] – 1**.

The **Fisher Effect** is a theoretical relationship between nominal returns, real returns and the expected inflation rate. Essentially, the effect can be stated as:

> "A rise in the rate of inflation causes the nominal rate to rise just enough so that the real rate of interest is unaffected. In other words, the real rate is invariant to the rate of inflation."

Inflation-Linked Bonds

Even with default-free government bonds, there is still inherent risk. Specifically, inflation risk suggests that inflation can deteriorate the value of money over the time it is invested. Thus, the real return is less than the nominal return. TIPS (treasury inflation-protected securities) enable investors to offset inflation risk by providing promised payments specified in real terms.

TIPS are long term fixed rate coupon Treasury bonds introduced in late nineties in response to the investors' demand for high credit quality debt securities that provide inflation protection. The par value of TIPS is indexed to the general level of prices measured by the Consumer Price Index (CPI), resulting in changing par value and hence coupon payments over time. The adjusted par value reflects the inflation rate, as measured by the change in CPI, for the preceding year. Hence, they offer real interest rate of return to investors. TIPS belong to the family of indexed (or index-lined) bonds.

For example - Let's say you invested $1,000 in January on a new, 10-year inflation-indexed note that has a 4% coupon. At mid-year, the CPI indicates that inflation has been 1 percent during the first six months. Your principal is adjusted upward to $1,010 and your interest payment (one-half of 4%) is based on that figure. So, your first semiannual interest payment is $20.20, i.e., 0.5 *4% *$1,010. At the end of the year, the CPI indicates that inflation was 3 percent, which brings the value of your principal to $1,030. Your second interest payment is $20.60, i.e., $1,030 *4% *0.5.

Determinants of Bond Yields (Ref: Section 8.5)

Term Structure of Interest Rates

Term structure of interest rates denotes the relationship between nominal interest rates on default-free, pure discount bonds and time to maturity, other factors being equal. Treasury yield curve plots yields on Treasury notes and bonds relative to their maturities. One could loosely interpret the Treasury yield curve as the graphical representation of the term structure of interest rates.

- In general, the Treasury yield curves are upward sloping, implying that long-term bond yields are usually higher than short-term bond yields. And such yield curves are referenced as normal yield curves.
- At times, short-term bond yields could be higher than long-term bond yields, resulting in an downward sloping yield curve, which is known as an inverted yield curve.
- When yields on all bonds are similar, a horizontal or flat yield curve will be observed.

Determinants of Bond Yields and Valuation

In addition to the real interest rate embedded in bond yields, there are additional factors that impact the valuation and hence the yield of a bond. Here are the definitions for the various risk premium components built into the valuation of bond–

- Credit (Default) Risk Premium is for compensating risk averse investors for the likelihood that the issuer cannot fulfill the obligations of interest payments and/or principal repayment.
- Interest (Maturity) Risk Premium is for compensating risk averse investors for the likelihood that interest rates, i.e., bond yields, move in an unfavorable direction -
    - Price Risk: Bond prices decline as yields rise; a concern for investing in bonds that have longer maturities than the holding horizon.
    - Reinvestment Risk: Reinvestment income declines as yields fall; a concern for investing in bonds that have shorter maturities than the holding horizon.
- Liquidity (Marketability) Risk Premium is for compensating risk averse investors for the likelihood that the holders cannot sell the bonds at the equilibrium price in a timely manner.
- Taxability Risk Premium is for compensating risk averse investors for the likelihood that the tax status of the returns, mainly interest payments, changes in an unfavorable manner.
- Foreign Exchange Risk Premium is for compensating risk averse investors for the likelihood that the foreign exchange rates move in an unfavorable direction, resulted from changes in economic and/or political conditions in the home and foreign countries.
- Inflation Risk Premium is for compensating risk averse investors for the likelihood that the purchasing power of the return and/or the value of the investment deteriorates due to expected inflation.

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