Chapter 7
Bond Valuation
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Topics Covered
★ Bond characteristics and pricing
★ Annual vs. semi-annual coupon bonds
★ Bond quotation and yield-to-maturity
★ Bond rates of returns
★ Interest rate risk of bonds
★ Credit ratings
★ Yield-to-call
★ Term structure of interest rate

Key Concepts and Skills
★ Know the important bond features and bond types
★ Understand bond values and why they fluctuate
★ Understand bond ratings and what they mean
★ Understand the impact of inflation on interest rates
★ Understand the term structure of interest rates and the determinants of bond yields

Bond Cash Flows
★ Annual coupons

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>...</th>
<th>T</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
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</table>

★ Semi-annual coupons

<table>
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<tr>
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<th>2</th>
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<th>2T</th>
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<tbody>
<tr>
<td>coupon/2</td>
<td>coupon/2</td>
<td>par+coupon/2</td>
<td>2T</td>
<td></td>
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</tbody>
</table>

★ Value today = PV of expected cash flows

\[ PV = \frac{coupon}{(1+r)} + \frac{coupon}{(1+r)^2} + ... + \frac{par+coupon}{(1+r)^T} \]

Bond Characteristics
★ Five basic variables
★ FV: par value (or face value) - usually $1000 to be paid at maturity
★ PMT: annual coupon = par value*coupon rate (paid periodically to bondholder)
★ T: years to maturity
★ r: required rate of return (discount rate)
★ PV: PV of future cash flows (value today)

Bond Pricing
Example
What is the price of a 6.5% annual coupon bond, with a $1,000 face value, which matures in 3 years? Assume a required return of 3.9%.

\[ PV = \frac{65}{(1.039)^1} + \frac{65}{(1.039)^2} + \frac{1065}{(1.039)^3} \]

\[ PV = $1,072.29 \]
Bond Pricing

Example (continued)

What is the price of the bond if the required rate of return is 6.5%?

\[ PV = \frac{65}{(1.065)^1} + \frac{65}{(1.065)^2} + \frac{1,065}{(1.065)^3} \]

\[ PV = $1,000 \]

Bond Pricing

Example (continued)

What is the price of the bond if the required rate of return is 15%?

\[ PV = \frac{65}{(1.15)^1} + \frac{65}{(1.15)^2} + \frac{1,065}{(1.15)^3} \]

\[ PV = $805.93 \]

Bond Price and Interest Rate

* There is a negative relationship between bond price and interest rate (discount rate)
* If discount rate is higher (lower) than coupon rate, bond prices should be less (more) than par value
* When discount rate equals to coupon rate, bond prices equal to par value

Bond Price Over Time

Both premium and discount bonds approach face value as their maturity date approaches

Annual vs. Semiannual coupon

Q: How does the calculation change, given semiannual coupons versus annual coupon payments?

<table>
<thead>
<tr>
<th>Time Periods</th>
<th>Discount Rate</th>
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<tbody>
<tr>
<td>Pay coupons twice a year</td>
<td>* discount rate changes from the annual rate to the half year rate.</td>
</tr>
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</table>
**Bond Yields**

- **Current Yield**
  - Annual coupon payments divided by bond price.

- **Yield To Maturity (YTM)**
  - Interest rate for which the present value of bond equals the market price.
  - Total annual expected return if you buy the bond today and hold to the maturity date.

**Bond Quotation**

- T-bond quotation (at Mar 2014)
  - Maturity: May 2030
  - Coupon rate: 6.25%
  - Bid and asked quotes
    - Bid price is the price dealers would like to buy, and asked price is the price dealers would like to sell.
    - Ask price > bid price, so we have bid-ask spread.
    - Quoted price is 136.9141% of face value.
    - Change is -0.7813% of face value.

**Yield To Maturity**

- T-bond (suppose we were at March, 2014)
  - T-bond: bond price = -1369.1411 (=PV)
  - Annual coupon = 6.25% * 1000 = 62.5
  - N = 2 * 16 = 32, PMT = 62.5 / 2 = 31.25, FV = 1000
    → r = 1.6344%

- The YTM to meet the current price is 3.2688% (1.6344% * 2)

**Rate of Return Example**

- Imagine buying these bonds at the current prices today. A year later, assume the yield to maturity for each bond increases by 0.5 percentage point.

- What is the expected price of each bond and what would be the rate of return for each bond if they were sold a year from today?
**Rate of Return Example**

- **Expected YTMs**
  - T-bond: 3.289% + 0.5% = 3.789%
  - T-bonds
    - 1 Yr price = 1279.6284 (if YTM = 3.789%), why?
    - N = 2 * 15 = 30, PMT = 31.25, FV = 1000, 
      \( r = \frac{3.789\%}{2} = 1.8945\% \)
    - Now, N = 2, PMT = 31.25, PV = -1369.141, 
      FV = 1279.6284 
    - \( r = -1.00295\% \), APR = -2.0059%, EAR = -1.9958%

**Corporate Bond**

- **Corporate bond quotation (Sep 2005)**
  - Company  | Coupon  | Maturity  | Last price | Last yield |
  - Wal-mart  | 7.55    | Sep 30, 2031 | 125.314    | 5.675      |

- Let’s verify the yield to maturity of the bond
- Again, assume the yield to maturity increases by 0.5 percentage point a year later.
- What is the expected price of each bond and what would be the rate of return if they were sold a year from today?

**Yield To Maturity Example**

- **Wal-mart bond**
  - What’s bond price? Also, verify the yield!
  - Wal-mart bond price =
  - Annual coupon =
  - \( N = \), PMT = , FV =
  - The YTM to meet the current price is

- **Expected YTMs**
  - What’s YTM 1 yr later? Assume increase by 0.5%
  - YTM =

**Rate of Return Example**

- **Wal-Mart**
  - What’s the price 1 yr later?
  - \( N = \), PMT = , FV =
  - \( r = \)
  - 1-Yr price =
  - What’s the return?
  - Now, N = , PMT = , PV = , FV =
  - \( r = \), APR = , EAR =

**Interest Rate Risk**

- Measures bond price sensitivity to changes in interest rates
- All things equal, long-term bonds have more interest rate risk than short-term bonds.
- All things equal, low coupon bonds also have more interest rate risk than high coupon bonds

**Interest Rate Risk Example**

- Let’s compare two bonds with everything the same except the time-to-maturity (1 vs. 30 years)
- PVs of 10% annual coupons with \( r \) at 5%, 10%, 15%, 20%.

<table>
<thead>
<tr>
<th>Interest Rate</th>
<th>1 Year</th>
<th>30 Years</th>
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<tbody>
<tr>
<td>5%</td>
<td>$1,047.62</td>
<td>$1,768.62</td>
</tr>
<tr>
<td>10</td>
<td>1,000.00</td>
<td>1,000.00</td>
</tr>
<tr>
<td>15</td>
<td>956.52</td>
<td>671.70</td>
</tr>
<tr>
<td>20</td>
<td>916.67</td>
<td>502.11</td>
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Bond Price Sensitivity

When the interest rate equals the 10% coupon rate, both bonds sell at face value.

Debt vs. Equity

- Debt is not an ownership interest (vs. stock)
- Creditors do not have voting rights (vs. common stock)
- Interest is considered to be a cost and is tax deductible (dividends are not deductible)
- Creditors have legal recourse if interest or principal payments are missed
- Excess debt can lead to financial distress and bankruptcy

The Bond Indenture

- Contract between the company and the bondholders, which specifies
  - The basic terms of the bonds
  - The total amount of bonds issued
  - A description of property used as security
  - Sinking fund provisions
  - Call provisions
  - Details of protective covenants

Bond Classifications

- Registered vs. bearer forms
  - Registered: payment is made to the owner of record
  -Bearer: payment is made to whoever holds the bond
- Security
  - Collateral: secured by financial securities
  - Mortgage: secured by real property
  - Debenture: unsecured
  - Note: unsecured debt with original maturity less than 10 years
- Seniority
- Sinking fund: repayment schedule for early redemption
- Call provision: firms buy back bond prior to maturity

Callable Bonds

- Company can buy back the bonds before maturity based on a call price.
- Call price is set above par (call premium)
- Call protection: not called in the first few years
- Calling is more likely as interest rates fall

Credit Rating (default risk)

- Credit ratings proxy for default risk, the risk that bond issuer may default on its obligations
- Default premium: difference between corporate bond yield and T-bond yield (assume same coupon, maturity)
- Bonds are generally classified into two groups
  - Investment grade bonds: AAA, AA, A, BBB
  - Junk (speculative grade) bonds: below BBB
- Investment grade bonds are generally legal for purchase by banks; junk bonds are not
**Coupon Rate**

- The coupon rate depends on the risk characteristics of the bond when issued
- Which bonds will have the higher coupon, all else equal?
  - Secured debt versus a debenture
  - Subordinated debenture versus senior debt
  - A bond with a sinking fund versus one without
  - A callable bond versus a non-callable bond

**Government Bonds**

- Treasury Securities
  - Issued by federal government
  - Examples: T-bills, T-notes, T-bonds
  - No default risk
- Municipal Securities (munis)
  - Issued by state or local governments
  - Varying degrees of default risk, rated similar to corporate debt
  - Coupons are tax-exempt at the federal level

**Municipal Bond Example**

- A taxable bond has a yield of 8% and a municipal bond has a yield of 6%. If you are in a 40% tax bracket, which bond do you prefer? At what tax rate would you be indifferent between the two bonds?
  - The after-tax return on the corporate bond is 4.8% (8% \times (1 - .4) = 4.8%). So, 6% return on the munis is more attractive
  - 8%(1 - T) = 6%, T = 25%

**Zero-Coupon Bonds**

- Make no periodic interest payments (coupon rate = 0%)
- The entire yield-to-maturity comes from the difference between the purchase price and the par value
- Cannot sell for more than par value
- Sometimes called zeroes, or deep discount bonds
- T-bills and principal only Treasury strips are good examples of zeroes

**Floating Rate Bonds**

- Coupon rate floats depending on some index value
- Examples – adjustable rate mortgages and inflation-linked Treasuries
- There is less price risk with floating rate bonds
  - The coupon floats, so it is less likely to differ substantially from the yield-to-maturity
  - Coupons may have a “collar” – the rate cannot go above a specified “ceiling” or below a specified “floor”

**Other Bond Types**

- Catastrophe bonds
- Income bonds
- Convertible bonds
- Put bond
- There are many other types of provisions that can be added to a bond and many bonds have several provisions
Bond Markets

- Primarily over-the-counter transactions with dealers connected electronically
- Extremely large number of bond issues, but generally low daily volume in single issues
- Makes getting up-to-date prices difficult, particularly on small company or municipal issues
- Treasury securities are an exception

Inflation

- Inflation: Rate at which prices as a whole are increasing.
- Nominal Interest Rate: Rate at which money invested grows.
- Real Interest Rate: Rate at which the purchasing power of an investment increases.

Fisher Effect (Inflation)

1 + real interest rate = \frac{1 + \text{nominal interest rate}}{1 + \text{inflation rate}}

Approximation formula

Real int. rate \approx \text{nominal int. rate} - \text{inflation rate}

Inflation - Example

- If the interest rate on one year government bonds is 5.0% and the inflation rate is 2.2%, what is the real interest rate?

\[
1 + \text{real interest rate} = \frac{1 + 0.05}{1 + 0.02} = 1.027
\]

real interest rate = 0.027 or 2.7%

Approximation = 0.05 - 0.02 = 0.02 or 2.0%

Term Structure of Interest Rates

- Term structure is the relationship between time to maturity and yields
- It is important to recognize that we remove the effect of default risk, different coupons, etc.
- Yield curve – graphical representation of the term structure
  - Normal – upward-sloping, long-term yields are higher than short-term yields
  - Inverted – downward-sloping, long-term yields are lower than short-term yields

Upward-Sloping Yield Curve
Downward-Sloping Yield Curve

Treasury Yield Curve

Yield Curve, Mar 2014

Corporate Bond Yield Factors

Quick Quiz

How do you find the value and yield of a bond?
How do you read bond quotation?
What are important features of bonds?
What are bond ratings?
What is the term structure of interest rates?
What are factors determining the required return on bonds?