CHAPTER 5

How Do Risk and Term Structure Affect Interest Rates?
Chapter Preview

In the last chapter, we examined interest rates, but made a big assumption—there is only one economy-wide interest rate. Of course, that isn’t really the case.

In this chapter, we will examine the different rates that we observe for financial products.
Chapter Preview

We will first examine bonds that offer similar payment streams but differ in price. The price differences are due to the **risk structure of interest rates**. We will examine in detail what this risk structure looks like and ways to examine it.
Chapter Preview

Next, we will look at the different rates required on bonds with different maturities. That is, we typically observe higher rates on longer-term bonds. This is known as the term structure of interest rates. To study this, we usually look at Treasury bonds to minimize the impact of other risk factors.
Chapter Preview

So, in sum, we will examine how the individual risk of a bond affects its required rate. We also explore how the general level of interest rates varies with the maturity of the debt instruments. Topics include:

— Risk Structure of Interest Rates
— Term Structure of Interest Rates
Risk Structure of Interest Rates

- To start this discussion, we first examine the yields for several categories of long-term bonds over the last 90 years.

- You should note several aspects regarding these rates, related to different bond categories and how this has changed through time.
Risk Structure of Long Bonds in the U.S.

**Figure 5.1** Long-Term Bond Yields, 1919–2010

The figure shows two important features of the interest-rate behavior of bonds.

- Rates on different bond categories change from one year to the next.
- Spreads on different bond categories change from one year to the next.
To further examine these features, we will look at three specific risk factors.

- Default Risk
- Liquidity
- Income Tax Considerations
Default Risk Factor

- One attribute of a bond that influences its interest rate is its **risk of default**, which occurs when the issuer of the bond is unable or unwilling to make interest payments when promised.

- U.S. Treasury bonds have usually been considered to have no default risk because the federal government can always increase taxes to pay off its obligations (or just print money). Bonds like these with no default risk are called **default-free bonds**.
The spread between the interest rates on bonds with default risk and default-free bonds, called the risk premium, indicates how much additional interest people must earn in order to be willing to hold that risky bond.

A bond with default risk will always have a positive risk premium, and an increase in its default risk will raise the risk premium.
Increase in Default Risk on Corporate Bonds

**FIGURE 5.2** Response to an Increase in Default Risk on Corporate Bonds

Initially $P_1 = P^T_1$ and the risk premium is zero. An increase in default risk on corporate bonds shifts the demand curve from $D^c_1$ to $D^c_2$. Simultaneously, it shifts the demand curve for Treasury bonds from $D^T_1$ to $D^T_2$. The equilibrium price for corporate bonds falls from $P^c_1$ to $P^c_2$, and the equilibrium interest rate on corporate bonds rises to $i^c_2$. In the Treasury market, the equilibrium bond price rises from $P^T_1$ to $P^T_2$ and the equilibrium interest rate falls to $i^T_2$. The brace indicates the difference between $i^c_2$ and $i^T_2$, the risk premium on corporate bonds. (Note that because $P^c_2$ is lower than $P^T_2$, $i^c_2$ is greater than $i^T_2$.)
Analysis of Figure 5.2: Increase in Default on Corporate Bonds

- **Corporate Bond Market**
  1. $R_e$ on corporate bonds $\downarrow$, $D_c \downarrow$, $D_c$ shifts left
  2. Risk of corporate bonds $\uparrow$, $D_c \downarrow$, $D_c$ shifts left
  3. $P_c \downarrow$, $i_c \uparrow$

- **Treasury Bond Market**
  1. Relative $R_e$ on Treasury bonds $\uparrow$, $D_T \uparrow$, $D_T$ shifts right
  2. Relative risk of Treasury bonds $\downarrow$, $D_T \uparrow$, $D_T$ shifts right
  $P_T \uparrow$, $i_T \downarrow$

- **Outcome**
  - Risk premium, $i_c - i_T$, rises
Default Risk Factor (cont.)

- Default risk is an important component of the size of the risk premium.
- Because of this, bond investors would like to know as much as possible about the default probability of a bond.
- One way to do this is to use the measures provided by credit-rating agencies: Moody’s and S&P are examples.
## Bond Ratings

<table>
<thead>
<tr>
<th>Rating</th>
<th>Moody’s</th>
<th>Standard and Poor’s</th>
<th>Descriptions</th>
<th>Examples of Corporations with Bonds Outstanding in 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aaa</td>
<td>AAA</td>
<td>Highest quality (lowest default risk)</td>
<td>Microsoft, Johnson &amp; Johnson, Mobil Corp.</td>
<td></td>
</tr>
<tr>
<td>Aa</td>
<td>AA</td>
<td>High quality</td>
<td>Shell Oil, Abbott Laboratories, General Electric</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>A</td>
<td>Upper-medium grade</td>
<td>Bank of America, Hewlett-Packard, McDonald’s, Inc.</td>
<td></td>
</tr>
<tr>
<td>Baa</td>
<td>BBB</td>
<td>Medium grade</td>
<td>Best Buy, FedEx, Harley Davidson</td>
<td></td>
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<tr>
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<td>BB</td>
<td>Lower-medium grade</td>
<td>Charter Communications, Colonial Penn, US Steel Corp.</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>B</td>
<td>Speculative</td>
<td>Rite Aid, Ford Motors, Delta</td>
<td></td>
</tr>
<tr>
<td>Caa</td>
<td>CCC, CC</td>
<td>Poor (high default risk)</td>
<td>Blockbuster, Century Indemnity, Everspan Financial Guarantee</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>D</td>
<td>Highly speculative</td>
<td>Citation Corp.</td>
<td></td>
</tr>
</tbody>
</table>
Case: The Subprime Collapse and the Baa-Treasury Spread

- Starting in 2007, the subprime mortgage market collapsed, leading to large losses for financial institutions.
- Because of the questions raised about the quality of Baa bonds, the demand for lower-credit bonds fell, and a “flight-to-quality” followed (demand for T-securities increased).
- Result: Baa-Treasury spread increased from 185 bps to 545 bps.
Liquidity Factor

- Another attribute of a bond that influences its interest rate is its liquidity; a liquid asset is one that can be quickly and cheaply converted into cash if the need arises. The more liquid an asset is, the more desirable it is (higher demand), holding everything else constant.
Corporate Bond Becomes Less Liquid

- **Corporate Bond Market**
  1. Liquidity of corporate bonds ↓, $D_c$ ↓, $D^c$ shifts left
  2. $P_c$ ↓, $i^c$ ↑

- **Treasury Bond Market**
  1. Relatively more liquid Treasury bonds, $D^T$ ↑, $D^T$ shifts right
  2. $P^T$ ↑, $i^T$ ↓

- **Outcome**
  - Risk premium, $i^c - i^T$, rises

- Risk premium reflects not only corporate bonds’ default risk but also lower liquidity
Liquidity Factor (cont.)

- The differences between interest rates on corporate bonds and Treasury bonds (that is, the risk premiums) reflect not only the corporate bond’s default risk but its liquidity too. This is why a risk premium is sometimes called a *risk and liquidity premium*. 
Income Taxes Factor

- An odd feature of Figure 5.1 is that municipal bonds tend to have a lower rate than the Treasuries. Why?
- Munis certainly can default. Orange County (California) is a recent example from the early 1990s.
- Munis are not as liquid as Treasuries.
Income Taxes Factor

- However, interest payments on municipal bonds are exempt from federal income taxes, a factor that has the same effect on the demand for municipal bonds as an increase in their expected return.

- Treasury bonds are exempt from state and local income taxes, while interest payments from corporate bonds are fully taxable.
Income Taxes Factor

- For example, suppose you are in the 35% tax bracket. From a 10%-coupon Treasury bond, you only net $65 of the coupon payment because of taxes.

- However, from an 8%-coupon muni, you net the full $80. For the higher return, you are willing to hold a riskier muni (to a point).
Tax Advantages of Municipal Bonds

(a) Market for municipal bonds

(b) Market for Treasury bonds

**FIGURE 5.3** Interest Rates on Municipal and Treasury Bonds

When the municipal bond is given tax-free status, demand for the municipal bond shifts rightward from $D^m_1$ to $D^m_2$, and demand for the Treasury bond shifts leftward from $D^T_1$ to $D^T_2$. The equilibrium price of the municipal bond rises from $P^m_1$ to $P^m_2$, so its interest rate falls, while the equilibrium price of the Treasury bond falls from $P^T_1$ to $P^T_2$ and its interest rate rises. The result is that municipal bonds end up with lower interest rates than those on Treasury bonds.
Analysis of Figure 5.3: Tax Advantages of Municipal Bonds

- Municipal Bond Market
  1. Tax exemption raises relative $R^e$ on municipal bonds, $D^m \uparrow$, $D^m$ shifts right
  2. $P^m \uparrow$

- Treasury Bond Market
  1. Relative $R^e$ on Treasury bonds $\downarrow$, $D^T \downarrow$, $D^T$ shifts left
  2. $P^T \downarrow$

- Outcome
  $i^m < i^T$
Case: Bush Tax Cut and Possible Repeal on Bond Interest Rates

- The 2001 tax cut called for a reduction in the top tax bracket, from 39% to 35% over a 10-year period.
- This reduces the advantage of municipal debt over T-securities since the interest on T-securities is now taxed at a lower rate.
Case: Bush Tax Cut and Possible Repeal on Bond Interest Rates

- If the Bush tax cuts are repealed under President Obama, our analysis would reverse. The advantage of municipal debt would increase relative to T-securities, since the interest on T-securities would be taxed at a higher rate.
Term Structure of Interest Rates

Now that we understand risk, liquidity, and taxes, we turn to another important influence on interest rates—maturity.

Bonds with different maturities tend to have different required rates, all else equal.
The WSJ: Following the News

For example, the WSJ publishes a plot of the **yield curve** (rates at different maturities) for Treasury securities.

The picture on page 97 of your text is a typical example, from May 14, 2010.

What is the 3-month rate? The two-year rate? What is the shape of the curve?
Besides explaining the shape of the yield curve, a good theory must explain why:

- Interest rates for different maturities move together. We see this on the next slide.
Interest Rates on Different Maturity Bonds Move Together

**Figure 5.4** Movements over Time of Interest Rates on U.S. Government Bonds with Different Maturities

Source: Federal Reserve: [www.federalreserve.gov/releases/h15/data.htm](http://www.federalreserve.gov/releases/h15/data.htm).
Term Structure Facts to Be Explained

Besides explaining the shape of the yield curve, a good theory must explain why:

- Interest rates for different maturities move together.
- Yield curves tend to have steep upward slope when short rates are low and downward slope when short rates are high.
- Yield curve is typically upward sloping.
Three Theories of Term Structure

1. Expectations Theory
   - Pure Expectations Theory explains 1 and 2, but not 3

2. Market Segmentation Theory
   - Market Segmentation Theory explains 3, but not 1 and 2

3. Liquidity Premium Theory
   - Solution: Combine features of both Pure Expectations Theory and Market Segmentation Theory to get Liquidity Premium Theory and explain all facts
Expectations Theory

- **Key Assumption:** Bonds of different maturities are perfect substitutes

- **Implication:** $R^e$ on bonds of different maturities are equal
Expectations Theory

To illustrate what this means, consider two alternative investment strategies for a two-year time horizon.

1. Buy $1 of one-year bond, and when it matures, buy another one-year bond with your money.
2. Buy $1 of two-year bond and hold it.
Expectations Theory

The important point of this theory is that if the Expectations Theory is correct, your expected wealth is the same (at the start) for both strategies. Of course, your actual wealth may differ, if rates change unexpectedly after a year.

We show the details of this in the next few slides.
Expectations Theory

- Expected return from strategy 1

\[(1 + i_2)(1 + i_{t+1}^e) - 1 = 1 + i_t + i_{t+1}^e + i_t(i_{t+1}^e) - 1\]

- Since \(i_t(i_{t+1}^e)\) is also extremely small, expected return is approximately

\[i_t + i_{t+1}^e\]
Expectations Theory

- Expected return from strategy 2

\[(1 + i_{2t})(1 + i_{2t}) - 1 = 1 + 2(i_{2t}) + (i_{2t})^2 - 1\]

- Since \((i_{2t})^2\) is extremely small, expected return is approximately \(2(i_{2t})\)
Expectations Theory

- From implication above expected returns of two strategies are equal

- Therefore

\[ 2(i_{2t}) = i_2 + i_{t+1}^e \]

Solving for \( i_{2t} \)

\[ i_{2t} = \frac{i_t + i_{t+1}^e}{2} \]
Expectations Theory

- To help see this, here’s a picture that describes the same information:

\[ i_{2t} = \frac{i_t + i_{t+1}^e}{2} \]
Example 5.2: Expectations Theory

- This is an example, with actual #’s:
More generally for \( n \)-period bond…

\[
i_{nt} = \frac{i_t + i_{t+1} + i_{t+2} + \ldots + i_{t+(n-1)}}{n}
\]

- Don’t let this seem complicated. Equation 2 simply states that the interest rate on a long-term bond equals the average of short rates expected to occur over life of the long-term bond.
More generally for $n$-period bond...

- Numerical example
  - One-year interest rate over the next five years are expected to be 5%, 6%, 7%, 8%, and 9%
  - Interest rate on two-year bond today:
    \[
    (5\% + 6\%)/2 = 5.5\%
    \]
  - Interest rate for five-year bond today:
    \[
    (5\% + 6\% + 7\% + 8\% + 9\%)/5 = 7\%
    \]
  - Interest rate for one- to five-year bonds today:
    5%, 5.5%, 6%, 6.5% and 7%
Expectations Theory and Term Structure Facts

- Explains why yield curve has different slopes
  1. When short rates are expected to rise in future, average of future short rates $= i_{nt}$ is above today's short rate; therefore yield curve is upward sloping.
  2. When short rates expected to stay same in future, average of future short rates same as today’s, and yield curve is flat.
  3. Only when short rates expected to fall will yield curve be downward sloping.
Expectations Theory and Term Structure Facts

- Pure expectations theory explains fact 1—that short and long rates move together

1. Short rate rises are persistent
2. If $i_t \uparrow$ today, $i_{t+1}^e, i_{t+2}^e$ etc. $\uparrow \Rightarrow$ average of future rates $\uparrow \Rightarrow i_{nt} \uparrow$
3. Therefore: $i_t \uparrow \Rightarrow i_{nt} \uparrow$
   (i.e., short and long rates move together)
Expectations Theory
and Term Structure Facts

- Explains fact 2—that yield curves tend to have steep slope when short rates are low and downward slope when short rates are high

1. When short rates are low, they are expected to rise to normal level, and long rate = average of future short rates will be well above today's short rate; yield curve will have steep upward slope.

2. When short rates are high, they will be expected to fall in future, and long rate will be below current short rate; yield curve will have downward slope.
Expectations Theory and Term Structure Facts

- Doesn’t explain fact 3—that yield curve usually has upward slope
  - Short rates are as likely to fall in future as rise, so average of expected future short rates will not usually be higher than current short rate: therefore, yield curve will not usually slope upward.
Market Segmentation Theory

- **Key Assumption:** Bonds of different maturities are not substitutes at all

- **Implication:** Markets are completely segmented; interest rate at each maturity are determined separately
Market Segmentation Theory

- Explains fact 3—that yield curve is usually upward sloping
  - People typically prefer short holding periods and thus have higher demand for short-term bonds, which have higher prices and lower interest rates than long bonds

- Does not explain fact 1 or fact 2 because its assumes long-term and short-term rates are determined independently.
Liquidity Premium Theory

- **Key Assumption:** Bonds of different maturities are substitutes, but are not perfect substitutes

- **Implication:** Modifies Pure Expectations Theory with features of Market Segmentation Theory
Liquidity Premium Theory

- Investors prefer short-term rather than long-term bonds. This implies that investors must be paid positive liquidity premium, $i_{nt}$ to hold long term bonds.
Liquidity Premium Theory

- Results in following modification of Expectations Theory, where $l_{nt}$ is the liquidity premium.

\[ i_{nt} = \frac{i_t + i_{t+1}^e + i_{t+2}^e + \ldots + i_{t+(n-1)}^e}{n} + l_{nt} \]

- We can also see this graphically…
Liquidity Premium Theory

**Figure 5.5** The Relationship Between the Liquidity Premium and Expectations Theory

Because the liquidity premium is always positive and grows as the term to maturity increases, the yield curve implied by the liquidity premium theory is always above the yield curve implied by the expectations theory and has a steeper slope. For simplicity, the yield curve implied by the expectations theory is drawn under the scenario of unchanging future one-year interest rates.
Numerical Example

1. One-year interest rate over the next five years: 5%, 6%, 7%, 8%, and 9%

2. Investors’ preferences for holding short-term bonds so liquidity premium for one-to five-year bonds: 0%, 0.25%, 0.5%, 0.75%, and 1.0%
Numerical Example

- Interest rate on the two-year bond:
  \[ 0.25\% + \frac{(5\% + 6\%)}{2} = 5.75\% \]

- Interest rate on the five-year bond:
  \[ 1.0\% + \frac{(5\% + 6\% + 7\% + 8\% + 9\%)}{5} = 8\% \]

- Interest rates on one to five-year bonds:
  5\%, 5.75\%, 6.5\%, 7.25\%, and 8\%

- Comparing with those for the pure expectations theory, liquidity premium theory produces yield curves more steeply upward sloped
Liquidity Premium Theory: Term Structure Facts

- Explains All 3 Facts
  - Explains fact 3—that usual upward sloped yield curve by liquidity premium for long-term bonds
  - Explains fact 1 and fact 2 using same explanations as pure expectations theory because it has average of future short rates as determinant of long rate
Market Predictions of Future Short Rates

(a) Future short-term interest rates expected to rise
(b) Future short-term interest rates expected to stay the same
(c) Future short-term interest rates expected to fall moderately
(d) Future short-term interest rates expected to fall sharply

**Figure 5.6** Yield Curves and the Market’s Expectations of Future Short-Term Interest Rates According to the Liquidity Premium Theory
Evidence on the Term Structure

- Initial research (early 1980s) found little useful information in the yield curve for predicting future interest rates.
- Recently, more discriminating tests show that the yield curve has a lot of information about very short-term and long-term rates, but says little about medium-term rates.
Case: Interpreting Yield Curves

- The picture on the next slide illustrates several yield curves that we have observed for U.S. Treasury securities in recent years.
- What do they tell us about the public’s expectations of future rates?
Case: Interpreting Yield Curves, 1980–2010

**Figure 5.7** Yield Curves for U.S. Government Bonds

Sources: Federal Reserve Bank of St. Louis; *U.S. Financial Data*, various issues; *Wall Street Journal*, various dates.
Case: Interpreting Yield Curves

- The steep downward curve in 1981 suggested that short-term rates were expected to decline in the near future. This played-out, with rates dropping by 300 bps in 3 months.

- The upward curve in 1985 suggested a rate increase in the near future.
Case: Interpreting Yield Curves

- The slightly upward slopes from 1985 through (about) 2006 is explained by liquidity premiums. Short-term rates were stable, with longer-term rates including a liquidity premium (explaining the upward slope).

- The steep upward slope in 2010 suggests short term rates in the future will rise.
Mini-case: The Yield Curve as a Forecasting Tool

- The yield curve does have information about future interest rates, and so it should also help forecast inflation and real output production.
  - Rising (falling) rates are associated with economic booms (recessions) [chapter 4].
  - Rates are composed of both real rates and inflation expectations [chapter 3].
Pure Expectations Theory: Invest in 1-period bonds or in two-period bond ⇒

\[(1 + i_t)(1 + i_{t+1}^e) - 1 = (1 + i_{2t})(1 + i_{2t}) - 1\]

- Solve for forward rate, \(i_{t+1}^e\)

\[i_{t+1}^e = \frac{(1 + i_{2t})^2}{1 + i_t} - 1\]

- Numerical example: \(i_{1t} = 5\%, \ i_{2t} = 5.5\%\)

\[i_{t+1}^e = \frac{(1 + 0.055)^2}{1 + 0.05} - 1 = 0.06 = 6\%\]
Forecasting Interest Rates with the Term Structure

- Compare 3-year bond versus 3 one-year bonds

\[(1 + i_t)(1 + i_{t+1}^e)(1 + i_{t+2}^e) - 1 = (1 + i_{3t})(1 + i_{3t})(1 + i_{3t}) - 1\]

- Using \(i_{t+1}^e\) derived in (4), solve for \(i_{t+2}^e\)

\[i_{t+2}^e = \frac{(1 + i_{3t})^3}{(1 + i_{2t})^2} - 1\]
Forecasting Interest Rates with the Term Structure

- Generalize to:

\[ i_{t+n}^e = \frac{(1 + i_{n+1t})^{n+1}}{(1 + i_{nt})^n} - 1 \]

- Liquidity Premium Theory: \( i_{nt} - l_{nt} = \) same as pure expectations theory; replace \( i_{nt} \) by \( i_{nt} - l_{nt} \) in (5) to get adjusted forward-rate forecast

\[ i_{t+n}^e = \frac{(1 + i_{n+1t} - l_{n+1t})^{n+1}}{(1 + i_{nt} - l_{nt})^n} - 1 \]
Forecasting Interest Rates with the Term Structure

- **Numerical Example**
  \[ l_2t = 0.25\%, \ l_1t = 0, \ i_{1t} = 5\%, \ i_{2t} = 5.75\% \]

  \[ i_{t+1}^e = \frac{\left(1 + 0.0575 - 0.0025\right)^2}{1 + 0.05} - 1 = 0.06 = 6\% \]

- **Example**: 1-year loan next year
  T-bond + 1\%, \ l_2t = .4\%, \ i_{1t} = 6\%, \ i_{2t} = 7\%

  \[ i_{t+1}^e = \frac{\left(1 + 0.07 - 0.004\right)^2}{1 + 0.06} - 1 = 0.072 = 7.2\% \]

  Loan rate must be > 8.2\%
Chapter Summary

- **Risk Structure of Interest Rates**: We examine the key components of risk in debt: default, liquidity, and taxes.

- **Term Structure of Interest Rates**: We examined the various shapes the yield curve can take, theories to explain this, and predictions of future interest rates based on the theories.