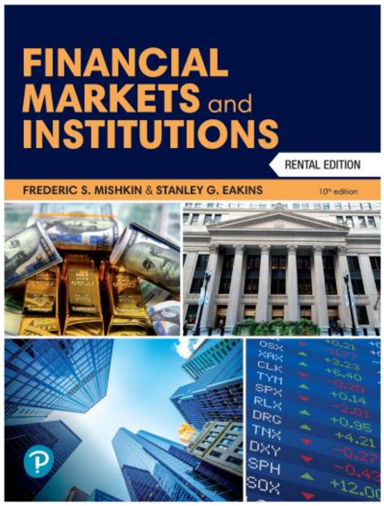
Financial Markets and Institutions

Tenth Edition



Part 2 Fundamentals of Financial Markets
Chapter 3

What Do Interest Rates Mean and What Is Their Role in Valuation?

Chapter Preview (1 of 3)

Interest rates are among the most closely watched variables in the economy. It is imperative that what exactly is meant by the phrase **interest rates** is understood.

In this chapter, we will see that a concept known as **yield to maturity** (YTM) is the most accurate measure of interest rates.

Chapter Preview (2 of 3)

- Any description of **interest rates** entails an understanding certain vernacular and definitions, most of which will not only pertain directly to interest rates but will also be vital to understanding many other foundational concepts presented later in the slide.

Chapter Preview (3 of 3)

- In this chapter, we will develop a better understanding of interest rates. We examine the terminology and calculation of various rates, and we show the importance of these rates in our lives and the general economy. Topics include:
  - Measuring Interest Rates
  - The Distinction Between Real and Nominal Interest Rates
  - The Distinction Between Interest Rates and Returns

Present Value Introduction

- Different debt instruments have very different streams of cash payments to the holder (known as **cash flows**), with very different timing.
- All else being equal, debt instruments are evaluated against one another based on the **amount** of each cash flow and the **timing** of each cash flow.
- This evaluation, where the analysis of the amount and timing of a debt instrument's cash flows lead to its **yield to maturity or interest rate**, is called **present value** analysis.

Present Value

- The concept of **present value** (or **present discounted value**) is based on the commonsense notion that a dollar of cash flow paid to you one year from now is less valuable to you than a dollar paid to you today. This notion is true because you could invest the dollar in a savings account that earns interest and have more than a dollar in one year.
- The term present value (PV) can be extended to mean the PV of a single cash flow or the **sum** of a sequence or group of cash flows.

Present Value Applications

There are four basic types of credit instruments which incorporate present value concepts:

1. Simple Loan
2. Fixed Payment Loan
3. Coupon Bond
4. Discount Bond

Present Value Concept: Simple Loan Terms

- **Loan Principal:** the amount of funds the lender provides to the borrower.
- **Maturity Date:** the date the loan must be repaid; the **Loan Term** is from initiation to maturity date.
- **Interest Payment:** the cash amount that the borrower must pay the lender for the use of the loan principal.
- **Simple Interest Rate:** the interest payment divided by the loan principal; the percentage of principal that must be paid as interest to the lender. Convention is to express on an annual basis, irrespective of the loan term.

Present Value Concept: Simple Loan (1 of 2)

Simple loan of $100

Year:	0	1	2	3	*n*
	$100	$110	$121	133	$100 \times (1+i)^n$

$$\text{PV of Future } \$1 = \frac{\$1}{(1+i)^n}$$

Present Value Concept: Simple Loan (2 of 2)

- The previous example reinforces the concept that $100 today is preferable to $100 a year from now since today's $100 could be lent (or deposited) at 10% interest to be worth $110 one year from now, or $121 in two years or $133 in three years.

Yield to Maturity: Loans (1 of 2)

Yield to maturity = interest rate that equates today's value with present value of all future payments

1. Simple Loan Interest Rate (i = 10%)
   $\$100 = \$110 / (1 + i)$, or $i = 10\%$

Example 3.1 Simple Present Value

What is the present value of $250 to be paid in two years if the interest rate is 15%?

$\$250 / (1 + 0.15)^2 = \$250 / 1.3225 = \$189.04$

Present Value Concept: Fixed-Payment Loan Terms (1 of 2)

- **Simple Loans** require payment of one amount which equals the loan principal plus the interest.
- **Fixed-Payment Loans** are loans where the loan principal and interest are repaid in several payments, often monthly, in equal dollar amounts over the loan term.

Present Value Concept: Fixed-Payment Loan Terms (2 of 2)

- **Installment Loans**, such as auto loans and home mortgages are frequently of the fixed-payment type.

Yield to Maturity: Loans (2 of 2)

2. Fixed Payment Loan (i = 12%)

$$\$1{,}000 = \frac{\$126}{(1+i)} + \frac{\$126}{(1+i)^2} + \frac{\$126}{(1+i)^3} + \ldots + \frac{\$126}{(1+i)^{25}}$$

$$LV = \frac{FP}{(1+i)} + \frac{FP}{(1+i)^2} + \frac{FP}{(1+i)^3} + \ldots + \frac{FP}{(1+i)^{n}}$$

Yield to Maturity: Bonds (1 of 2)

3. Coupon Bond (Coupon rate = $10\% = C/F$)

$$P = \frac{\$100}{(1+i)} + \frac{\$100}{(1+i)^2} + \frac{\$100}{(1+i)^3} + \ldots + \frac{\$100}{(1+i)^{10}} + \frac{\$1{,}000}{(1+i)^{10}}$$

$$P = \frac{C}{(1+i)} + \frac{C}{(1+i)^2} + \frac{C}{(1+i)^3} + \ldots + \frac{C}{(1+i)^{n}} + \frac{F}{(1+i)^{n}}$$

Consol: Fixed coupon payments of $C forever

$$P = \frac{C}{i} \qquad i = \frac{C}{P}$$

Yield to Maturity: Bonds (2 of 2)

4. One-Year Discount Bond (P = \$900, F = \$1,000)

$$\$900 = \$1{,}000 / (1 + i), \text{ or } i = 11.11\%$$

Table 3.1

Yields to Maturity on a 10% Coupon Rate Bond Maturing in 10 Years (Face Value = \$1,000)

Price of Bond(\$)	Yield to Maturity (%)
1,200	7.13
1,100	8.48
1,000	10.00
900	11.75
800	13.81

Three interesting facts in Table 3.1

1. When bond is at par, yield equals coupon rate
2. Price and yield are negatively related
3. Yield greater than coupon rate when bond price is below par value

Relationship Between Price and Yield to Maturity

- It's also straight-forward to show that the value of a bond (price) and yield to maturity (YTM) are negatively related. If the interest rate *i* increases (YTM increases), the PV of any given cash flow is lower; hence, the price of the bond must be lower.

Current Yield

- Current yield (CY) is just an approximation for YTM—easier to calculate. However, we should be aware of its properties:
  1. If a bond's price is near par and has a long maturity, then CY is a good approximation.
  2. A change in the current yield always signals change in same direction as yield to maturity

Formula: $i_c = C / P$

Yield on a Discount Basis

One-Year Bill (*P* = \$900, *F* = \$1,000, days = 365)

$$i_{db} = (\$1{,}000 - \$900) / \$1{,}000 \times (360/365) = 9.9\%$$

- Two Characteristics
  1. Understates yield to maturity; longer the maturity, greater is understatement
  2. Change in discount yield always signals change in same direction as yield to maturity

Global: Negative T-Bill Rates? It Can Happen (1 of 2)

- In November 1998, rates on Japanese six-month government bonds were negative! Investors were willing to pay **more** than they would receive in the future.
- Same thing happened in the U.S. in September of 2008, then Sweden (July 2009), Denmark (July 2012), the Eurozone (June 2014), Switzerland (December 2014), and Japan again in early 2016.

Global: Negative T-Bill Rates? It Can Happen (2 of 2)

- Best explanation is that investors found the convenience of the Treasury bills (in the U.S. case) worth something—more convenient than cash. But that can only go so far—the rate was only slightly negative.

Distinction Between Real and Nominal Interest Rates (1 of 3)

- Real interest rate
  1. Interest rate that is adjusted for expected changes in the price level

$$i_r = i - \pi^e$$

  2. Real interest rate more accurately reflects true cost of borrowing
  3. When the real rate is low, there are greater incentives to borrow and less to lend

Distinction Between Real and Nominal Interest Rates (2 of 3)

- Real interest rate

$$i_r = i - \pi^e$$

We usually refer to this rate as the ***ex ante*** real rate of interest because it is adjusted for the **expected** level of inflation. After the fact, we can calculate the **ex post** real rate based on the observed level of inflation.

Distinction Between Real and Nominal Interest Rates (3 of 3)

If i = 5% and $\pi^e = 0\%$ then

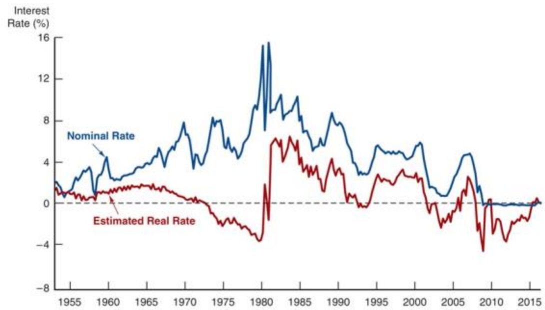
$$5\% - 0\% = 5\%$$

If i = 10% and $\pi^e = 20\%$ then

$$10\% - 20\% = -10\%$$

Figure 3.1 (1 of 2)

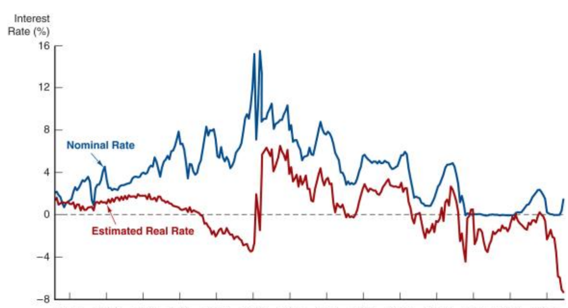
Real and Nominal Interest Rates (Three-Month Treasury Bill), 1953–2022



Sources: Federal Reserve Bank of St. Louis FRED database https://fred.stlouisfed.org/series/TB3MS and https://fred.stlouisfed.org/series/CPIAUCSL . The real rate is constructed using the procedure outlined in Frederic S. Mishkin, "The Real Interest Rate: An Empirical Investigation," **Carnegie–Rochester Conference Series on Public Policy** 15 (1981): 151–200. This involves estimating expected inflation as a function of past interest rates, inflation, and time trends and then subtracting the expected inflation measure from the nominal interest rate.

Figure 3.1 (2 of 2)

Real and Nominal Interest Rates (Three-Month Treasury Bill), 1953–2022



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Distinction Between Interest Rates and Returns

Rate of Return: we can decompose returns into two pieces:

$$\text{Return} = C / P_t + \left(P_t + 1 - P_t\right) / P_t$$

Return = Current Yield + Capital Gain Yield

Table 3.2

One-Year Returns on Different-Maturity 10% Coupon Rate Bonds When Interest Rates Rise from 10% to 20%

Original maturity	Initial Current Yield (%)	Initial Price ($)	Price Next Year ($)	Rate of Capital Gain (%)	Rate of Return (%)
30	10	1,000	503	−49.7	−39.7
20	10	1,000	516	−48.4	−38.4
10	10	1,000	597	−40.3	−30.3
5	10	1,000	741	−25.9	−15.9
2	10	1,000	917	−8.3	1.7
1	10	1,000	1,000	0	10

Sample of current coupon rates and yields on government bonds http://www.bloomberg.com/markets/iyc.html

Maturity and the Volatility of Bond Returns (1 of 3)

- Key findings from Table 3.2
  1. Only bond whose return = yield is one with maturity = holding period
  2. For bonds with maturity > holding period, as rates increase, price falls, implying capital loss
  3. Longer is maturity, greater is price change associated with interest rate change

Maturity and the Volatility of Bond Returns (2 of 3)

- Key findings from Table 3.2
  4. Longer is maturity, more return changes with change in interest rate
  5. Bond with high initial interest rate can still have negative return if i ↑

Maturity and the Volatility of Bond Returns (3 of 3)

- Conclusion from Table 3.2 analysis
  1. Prices and returns more volatile for long-term bonds because they have higher interest-rate risk
  2. No interest-rate risk for any bond whose maturity equals holding period

Reinvestment Risk

- Occurs if investor holds a series of short bonds over long holding period
- *i* at which reinvest uncertain
- Gain from *i* ↑, lose when *i* ↓

Table 3.3

Calculating Duration on a $1,000 Ten-Year 10% Coupon Bond When Its Interest Rate Is 10%

(1) Year	(2) Cash Payments (Zero-Coupon Bonds) ($)	(3) Present Value (*PV*) of Cash Payments (i = 10%) ($)	(4) Weights (% of total $PV = PV / \$1{,}000$) (%)	(5) Weighted Maturity $(1 \times 4)/100$ (years)
1	100	90.91	9.091	0.09091
2	100	82.64	8.264	0.16528
3	100	75.13	7.513	0.22539
4	100	68.30	6.830	0.27320
5	100	62.09	6.209	0.31045
6	100	56.44	5.644	0.33864
7	100	51.32	5.132	0.35924
8	100	46.65	4.665	0.37320
9	100	42.41	4.241	0.38169
10	100	38.55	3.855	0.38550
10	1,000	385.54	38.554	3.85500
Total	-	1,000.00	100.000	6.75850

Table 3.4

Calculating Duration on a $1,000 Ten-Year 10% Coupon Bond When Its Interest Rate Is 20%

(1) Year	(2) Cash Payments (Zero-Coupon Bonds) ($)	(3) Present Value (*PV*) of Cash Payments (i = 20%) ($)	(4) Weights (% of total $PV = PV / \$580.76$) (%)	(5) Weighted Maturity $(1 \times 4)/100$ (years)
1	100	83.33	14.348	0.14348
2	100	69.44	11.957	0.23914
3	100	57.87	9.965	0.29895
4	100	48.23	8.305	0.33220
5	100	40.19	6.920	0.34600
6	100	33.49	5.767	0.34602
7	100	27.91	4.806	0.33642
8	100	23.26	4.005	0.32040
9	100	19.38	3.337	0.30033
10	100	16.15	2.781	0.27810
10	1,000	161.51	27.808	2.78100
Total	-	580.76	100.000	5.72204

Formula for Duration (1 of 2)

$$DUR = \sum_{t=1}^{n} t \frac{CP_t}{(1+i)^t} / \sum_{t=1}^{n} \frac{CP_t}{(1+i)^t}$$

Key facts about duration

1. All else equal, when the maturity of a bond lengthens, the duration rises as well
2. All else equal, when interest rates rise, the duration of a coupon bond fall

Formula for Duration (2 of 2)

1. The higher the coupon rate on the bond, the shorter the duration of the bond
2. Duration is additive: the duration of a portfolio of securities is the weighted-average of the durations of the individual securities, with the weights equaling the proportion of the portfolio invested in each security

Duration and Interest-Rate Risk (1 of 3)

Duration can be used to show that the approximate change in price is related to duration, as follows:

$$\%\Delta \text{Price} = -DUR \times \left(\Delta i \, / \, (1 + i) \right)$$

- $i \uparrow$ 10% to 11%:
  - Table 3.4, −10% coupon bond
  - $\%\Delta \text{Price} = -6.76 \times \left(0.01/1.10\right) = -6.15\%$

Duration and Interest-Rate Risk (2 of 3)

- $i \uparrow$ 10% to 11%:
  - 20% coupon bond, *DUR* = 5.72 years
  - $\%\Delta \text{Price} = -5.72 \times \left(0.01/1.10\right) = -5.20\%$

Duration and Interest-Rate Risk (3 of 3)

- The greater the duration of a security, the greater the percentage change in the market value of the security for a given change in interest rates
- Therefore, the greater the duration of a security, the greater its interest-rate risk

Chapter Summary (1 of 2)

- Measuring Interest Rates: We examined several techniques for measuring the interest rate required on debt instruments.
- The Distinction Between Real and Nominal Interest Rates: We examined the meaning of interest in the context of price inflation.

Chapter Summary (2 of 2)

- The Distinction Between Interest Rates and Returns: We examined what each means and how they should be viewed for asset valuation.

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