Money duration is stated in currency units and is sometimes expressed per 100 of bond value:

money duration = annual ModDur × full price of bond position

The price value of a basis point is the change in the value of a bond, expressed in currency units, for a change in YTM of one basis point:

$$PVBP = [(V_- - V_+) / 2] \times \text{par value} \times 0.01$$

PVBP can also be calculated as money duration × 0.0001.

LOS 57.b

Holding other factors constant, the following are true:

- Duration increases when maturity increases.
- Duration decreases when the coupon rate increases.
- Duration decreases when YTM increases.
- Duration decreases as time passes, but increases slightly on coupon dates.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 57.1

1. **B**

$V_- = 100.979$

$N = 6;\ PMT = 14.00;\ FV = 100;\ I/Y = 13.75;\ CPT \rightarrow PV = -100.979$

$V_+ = 99.035$

$I/Y = 14.25;\ CPT \rightarrow PV = -99.035$

$V_0 = 100.000$

$\Delta y = 0.0025$

$$\text{So, approximate ModDur} = \frac{V_- - V_+}{2V_0 \Delta YTM} = \frac{100.979 - 99.035}{2(100)(0.0025)} = 3.888.$$

(LOS 57.a)

2. **B** PVBP = initial price − price if yield is changed by 1 basis point.

First, we need to calculate the yield so we can calculate the price of the bond with a 1 basis point change in yield. Using a financial calculator, PV = −1,029.23; FV = 1,000; PMT = 27.5 = (0.055 × 1,000) / 2; N = 14 = 2 × 7 years; and CPT → I/Y = 2.49998, multiplied by 2 = 4.99995, or 5.00%.

Next, compute the price of the bond at a yield of 5.00% + 0.01%, or 5.01%. Using the calculator: FV = 1,000; PMT = 27.5; N = 14; I/Y = 2.505 (5.01 / 2); CPT → PV = $1,028.63.

Next, compute the price of the bond at a yield of 5.00% − 0.01%, or 4.99%. Using the calculator: FV = 1,000; PMT = 27.5; N = 14; I/Y = 2.495 (4.99 / 2); CPT → PV = $1,029.82.

Finally, PVBP = ($1,029.82 − $1,028.63) / 2 = $0.595.

(LOS 57.a)

3. **C** −7.87 × (−1.10%) = 8.657%

(LOS 57.a)

4. **B** The price risk of the FRN is very low because at the next coupon payment date, the coupons will reset to market rates, and the FRN price will reset to par. Lower coupons, all else equal, lead to greater price risk. Therefore the 2-year zero-coupon bond will have more price risk than the 2-year 10% semiannual-pay bond. (LOS 57.b)

READING 58

YIELD-BASED BOND CONVEXITY AND PORTFOLIO PROPERTIES

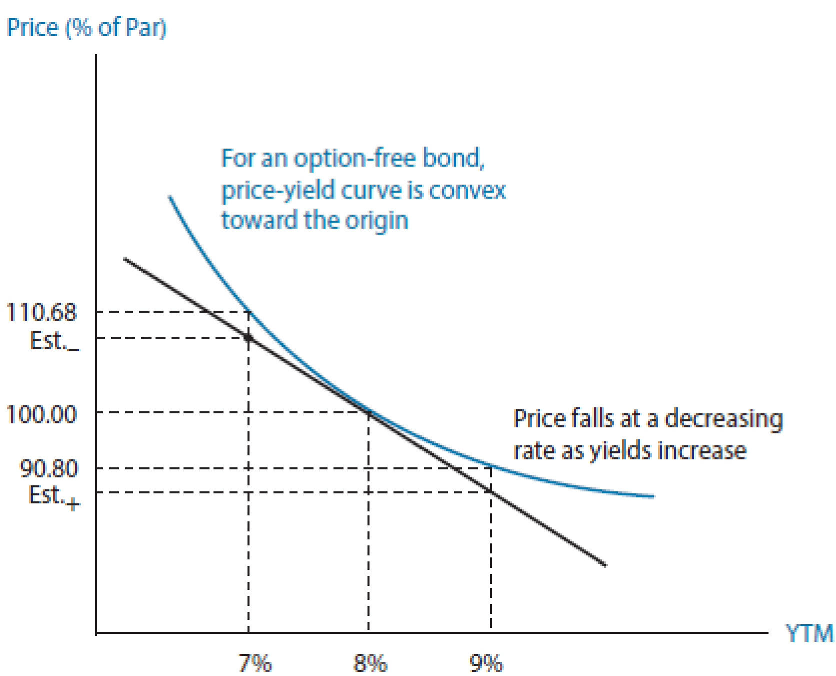
MODULE 58.1: YIELD-BASED BOND CONVEXITY AND PORTFOLIO PROPERTIES

Video covering this content is available online.

LOS 58.a: Calculate and interpret convexity and describe the convexity adjustment.

In our reading on Yield-Based Bond Duration Measures and Properties, we showed that modified duration is a linear approximation of the price-yield relationship. Because the true relationship is convex, duration-based estimates of a bond's full price will be increasingly different from actual prices as we increase the changes in yield. This is illustrated in Figure 58.1. Duration-based price estimates for a decrease and for an increase in YTM are shown as $Est._{-}$ and $Est._{+}$.

Figure 58.1: Price-Yield Curve for an Option-Free, 8%, 20-Year Semiannual-Pay Bond



We can improve our estimates of the price impact of a change in yield by introducing a second term. **Convexity** is a measure of the curvature of the price-yield relation. The more curved it is, the greater the convexity adjustment.

One way to calculate convexity is by considering each of a bond's cash flows separately. The convexity of a single cash flow at period *t* is given by the following:

$$\text{convexity of cash flow at period } t = \frac{t \times (t+1)}{(1+r)^2}$$

where *r* is the periodic yield of the cash flow (YTM/periodicity).

The convexity of a coupon-paying bond can then be calculated as the weighted average convexity of its individual cash flows, using the present value of cash flows as the weights (the same weighting we use to calculate Macaulay duration).

For a 5-year, 11% annual coupon bond priced at 86.59 (a 15% yield to maturity), the convexity of the coupon at Time 1 is $(1 \times 2) / 1.15^2 = 1.512$, and the convexity of the coupon at Time 2 is $(2 \times 3) / 1.15^2 = 4.537$. The following table completes the calculations for all five of the bond's cash flows:

					Convexity
$C_1 = 11$	$PV_1 = 11 / 1.15$	$= 9.565$	$W_1 = 9.565 / 86.59$	$= 0.1105$	**1.512**
$C_2 = 11$	$PV_2 = 11 / 1.15^2$	$= 8.318$	$W_2 = 8.318 / 86.59$	$= 0.0961$	**4.537**
$C_3 = 11$	$PV_3 = 11 / 1.15^3$	$= 7.233$	$W_3 = 7.233 / 86.59$	$= 0.0835$	**9.074**
$C_4 = 11$	$PV_4 = 11 / 1.15^4$	$= 6.289$	$W_4 = 6.289 / 86.59$	$= 0.0726$	**15.123**
$C_5 = 111$	$PV_5 = 111 / 1.15^5$	$= \underline{55.187}$	$W_5 = 55.187 / 86.59$	$= \underline{0.6373}$	**22.684**
		86.59		**1.0000**	

Using the weights given in the table, we can calculate the convexity for this bond as follows:

$$0.1105(1.512) + 0.0961(4.537) + 0.0835(9.074) + 0.0726(15.123) + 0.6373(22.684) = 16.915$$

For bonds with non-annual coupons, convexity needs to be divided by the number of periods per year *squared* to annualize the measure. For a semiannual coupon bond, the final convexity figure would be annualized by dividing by $2^2 = 4$.

In a similar way to how we approximated modified duration, we can also determine a bond's **approximate convexity** using the following formula:

$$\text{approximate convexity} = \frac{V_- + V_+ - 2V_0}{(\Delta YTM)^2 V_0}$$

where:
V_- = price of the bond if YTM is decreased by ΔYTM
V_+ = price of the bond if the YTM is increased by ΔYTM
V_0 = current price of the bond

EXAMPLE: Calculating approximate convexity

Consider our 5-year, 11% annual coupon bond priced at 86.59138 to yield 15% to maturity. If its YTM increases by 50 basis points, its price will decrease to 85.09217.

If its YTM decreases by 50 basis points, its price will increase to 88.12721. Calculate the approximate convexity of the bond.

Answer:

The approximate convexity is:

$$\frac{88.12721 + 85.09217 - (2 \times 86.59138)}{86.59138 \times 0.005^2} = 16.916$$

This result is nearly the same as the convexity measure we calculated by considering each cash flow separately.

A bond's convexity is increased or decreased by the same bond characteristics that affect duration. A longer maturity, a lower coupon rate, or a lower YTM will all increase convexity, and vice versa. For two bonds with equal duration, the one with cash flows that are more dispersed over time will have more convexity.

LOS 58.b: Calculate the percentage price change of a bond for a specified change in yield, given the bond's duration and convexity.

By taking account of both a bond's duration (first-order effects) and convexity (second-order effects), we can improve an estimate of the effects of a change in yield on a bond's value, especially for larger changes in yield:

$$\begin{aligned}\text{percent change in full bond price} = & -\text{annual modified duration}\,(\Delta\text{YTM}) \\ & + \frac{1}{2}\,\text{annual convexity}\,(\Delta\text{YTM})^2\end{aligned}$$

EXAMPLE: Estimating price changes with duration and convexity

Consider our 5-year, 11% annual coupon bond priced at 86.59138 to yield 15% to maturity. We have calculated the modified duration to be 3.50 and the convexity of the bond to be 16.9. Estimate the new price of the bond if its yield decreases by 50 basis points.

Answer:

The duration effect is –3.50 × –0.005 = 1.75%.

The convexity effect is 1/2 × 16.9 × $(-0.005)^2$ = 0.000211 = 0.0211%.

The expected change in bond price is (1.75% + 0.0211%) = 1.7711%.

The new price of the bond is estimated to be 86.59138 × 1.017711 = 88.125.

Analogous to money duration (MoneyDur), the **money convexity** (MoneyCon) of a bond position is expressed in currency units:

money convexity = annual convexity × full price of bond position

We can use money duration and money convexity to estimate the change in price of a bond as follows:

$$\text{change in full price of bond} = -(\text{MoneyDur} \times \Delta\text{YTM}) + \left(\frac{1}{2} \times \text{MoneyCon} \times \Delta\text{YTM}^2\right)$$

EXAMPLE: Estimating price changes with duration and convexity

For the bond in our previous examples, calculate the money duration and money convexity of a $10 million par position in the bond and estimate the new price of the bond for a 50 basis point decrease in yield. Recall that the modified duration of the bond is 3.50 and its convexity is 16.9.

Answer:

The market value of the position is 0.8659138 × 10,000,000 = $8,659,138.

The money duration of the position is 3.50 × $8,659,138 = $30,306,983.

The money convexity of the bond is 16.9 × $8,659,138 = $146,339,432.

The duration effect is −($30,306,983 × −0.005) = $151,534.92.

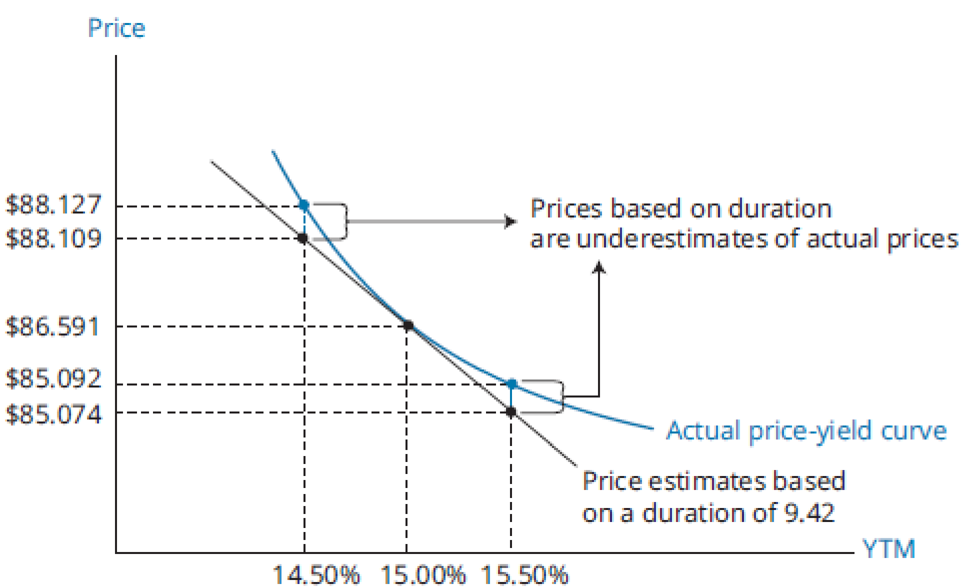
The convexity effect is $\frac{1}{2}$ × $146,339,432 × (−0.005)^2 = $1,829.25.

The expected change in bond price is ($151,534.92 + $1,829.25) = $153,364.17.

The new value of the bond is estimated to be $8,659,138 + $153,364.17 = $8,812,502. This is consistent with the estimate for new price of 88.125 in the previous example. Both methods are doing the same thing in a slightly different way.

The convexity adjustment to the price change is the same for either an increase or a decrease in yield. As illustrated in Figure 58.2, the duration-only based estimate of the increase in price resulting from a decrease in yield is too low for a bond with positive convexity, and it is improved by a positive adjustment for convexity. The duration-only based estimate of the decrease in price resulting from an increase in yield is larger than the actual decrease, so it is also improved by a positive adjustment for convexity.

Figure 58.2: Duration-Based Price Estimates vs. Actual Bond Prices



LOS 58.c: Calculate portfolio duration and convexity and explain the limitations of these measures.

There are two approaches to estimating the duration and convexity of a portfolio. The first is to base a single duration and convexity calculation on the portfolio's aggregate cash flows across all bonds. The second approach is to calculate the duration and convexity of each bond in the portfolio, then take a weighted average of these based on the weight of the bond in the portfolio.

The first approach is theoretically correct; however, the second approach is typically used in practice because it is often easier to apply. The second approach can be formulated as follows:

$$\text{portfolio duration} = W_1 D_1 + W_2 D_2 + \ldots + W_N D_N$$

where:

W_i = full price of bond *i* divided by the total value of the portfolio
D_i = duration of bond *i*
N = number of bonds in the portfolio

One limitation of this approach is that it assumes the YTM of every bond (of any maturity) in the portfolio must change by the same amount. Only under this assumption of a **parallel shift** in the yield curve will portfolio duration and convexity calculated with this approach produce the percentage change in portfolio value per 1% change in YTM.

Changes in the yield curve are rarely a simple parallel shift. Changes in shape, such as a steepening or twist, are common.

MODULE QUIZ 58.1

1. The annualized convexity of a 2-year, annual-pay, 10% coupon bond trading at par is *closest* to:
   A. 1.65.
   B. 4.66.
   C. 4.96.
2. A bond is trading at a price of 104.4518. If its yield increases by 10 basis points, its price will decrease to 103.9954. If its yield decreases by 10 basis points, its prices will increase to 104.9108. The approximate convexity of this bond is *closest* to:
   A. 12.45.
   B. 24.89.
   C. 49.78.
3. The annualized convexity of a 2-year, semiannual-pay, 10% coupon bond trading at par is *closest* to:
   A. 4.12.
   B. 4.66.
   C. 16.47.
4. A bond has a convexity of 114.6. The convexity effect, if the yield decreases by 110 basis points, is *closest* to:
   A. −1.673%.
   B. +0.693%.

C. +1.673%.

5. Portfolio duration based on weighted average durations of constituents of the portfolio assumes:
   A. yields change uniformly across all maturities.
   B. the portfolio does not include bonds with embedded options.
   C. the portfolio's internal rate of return is equal to its cash flow yield.

KEY CONCEPTS

LOS 58.a

Convexity refers to the curvature of a bond's price-yield relationship.

The convexity of a single cash flow at period *t* is given by the following:

$$\text{convexity of cash flow at period } t = \frac{t \times (t+1)}{(1+r)^2}$$

where:
t = period at which the cash flow occurs
r = periodic yield of the bond (YTM/periodicity)

The convexity of a coupon-paying bond is the weighted average convexity of its cash flows.

To annualize convexity for non-annual coupons, divide by periodicity squared.

Convexity can be approximated using the following formula:

$$\text{approximate convexity} = \frac{V_- + V_+ - 2V_0}{(\Delta\text{YTM})^2 V_0}$$

where:
V_- = price of the bond if YTM is decreased by ΔYTM
V_+ = price of the bond if the YTM is increased by ΔYTM
V_0 = current price of the bond

LOS 58.b

Given values for approximate annual modified duration and approximate annual convexity, the percentage change in the full price of a bond can be estimated as follows:

$$\%\Delta \text{ full bond price} = -\text{annual modified duration } (\Delta\text{YTM}) + \frac{1}{2}\text{ annual convexity }(\Delta\text{YTM})^2$$

Money convexity is stated in currency units and is sometimes expressed per 100 of bond value:

money convexity = annual convexity × full price of bond position

Using money duration and money convexity to directly estimate the change in price of a bond, this is the equation:

$$\text{change in full price of bond} = -(\text{MoneyDur} \times \Delta\text{YTM}) + \left(\frac{1}{2} \times \text{MoneyCon} \times \Delta\text{YTM}^2\right)$$

LOS 58.c

There are two methods for calculating portfolio duration and convexity:

1. Calculate a single duration and convexity measure based on the aggregate cash flows of the bond portfolio.
2. Calculate the weighted average of durations of bonds in the portfolio. This method is used most often in practice, but it assumes a parallel shift of the yield curve.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 58.1

1. **B** Because the bond is trading at par, its yield is equal to its coupon of 10%. The convexity of the first cash flow at Time 1 is $(1 \times 2) / (1.10)^2 = 1.653$. The convexity of the second cash flow is $(2 \times 3) / (1.10)^2 = 4.959$. The weights for each cash flow time are calculated as follows:

					Convexity
$C_1 = 10$	$PV_1 = 10 / 1.10$	$= 9.091$	$W_1 = 9.091 / 100$	$= 0.09091$	**1.653**
$C_2 = 110$	$PV_2 = 110 / 1.10^2$	$= \underline{90.909}$	$W_2 = 90.909 / 100$	$= 0.90909$	**4.959**
		100			

The convexity of the bond is 0.09091(1.653) + 0.90909(4.959) = 4.66.(LOS 58.a)

2. **B** The approximate convexity of the bond is calculated as follows:

$$\text{approximate convexity} = \frac{V_- + V_+ - 2V_0}{(\Delta YTM)^2 V_0}$$

where:

V_- = price of the bond if YTM is decreased by ΔYTM

V_+ = price of the bond if the YTM is increased by ΔYTM

V_0 = current price of the bond

$$\text{In this case, approximate convexity} = \frac{104.9108 + 103.9954 - 2(104.4518)}{0.001^2 \times 104.4518} = 24.89.$$

(LOS 58.a)

3. **A** Because the bond is trading at par, its yield is equal to its coupon of 10%. Note that this is a semiannual coupon bond; hence, it has coupons of \$5 every six months and has a periodic six-month return of 5%. The weights for each cash flow time are calculated as follows:

					Convexity
$C_1 = 5$	$PV_1 = 5 / 1.05$	$= 4.762$	$W_1 = 4.762 / 100$	$= 0.0476$	**1.8141**
$C_2 = 5$	$PV_2 = 5 / 1.05^2$	$= 4.535$	$W_2 = 4.535 / 100$	$= 0.0454$	**5.4422**
$C_3 = 5$	$PV_3 = 5 / 1.05^3$	$= 4.319$	$W_3 = 4.319 / 100$	$= 0.0432$	**10.8844**
$C_4 = 105$	$PV_4 = 105 / 1.05^4$	$= \underline{86.384}$	$W_4 = 86.384 / 100$	$= 0.8638$	**18.1406**
		100			

The convexity of the first cash flow at Time 1 is $(1 \times 2) / (1.05)^2 = 1.8141$.

The convexity of the second cash flow is $(2 \times 3) / (1.05)^2 = 5.4422$.

The convexity of the third cash flow is $(3 \times 4) / (1.05)^2 = 10.8844$.

The convexity of the fourth cash flow is $(4 \times 5) / (1.05)^2 = 18.1406$.

The convexity of the bond is $0.0476(1.8141) + 0.0454(5.4422) + 0.0432(10.8844) + 0.8638(18.1406) = 16.47$.

The annualized convexity is calculated by dividing convexity by the periodicity of the bond (2) squared.

Hence, annualized convexity = $16.47 / 2^2 = 4.12$.

(LOS 58.a)

4. **B** The convexity effect = $1/2 \times \text{convexity} \times (\Delta YTM)^2 = (0.5)(114.6)(-0.011)^2 = 0.00693 = 0.693\%$.

(LOS 58.b)

5. **A** Portfolio duration is limited as a measure of interest rate risk because it assumes parallel shifts in the yield curve; that is, the discount rate at each maturity changes by the same amount. (LOS 58.c)

READING 59

CURVE-BASED AND EMPIRICAL FIXED-INCOME RISK MEASURES

MODULE 59.1: CURVE-BASED AND EMPIRICAL FIXED-INCOME RISK MEASURES

Video covering this content is available online.

LOS 59.a: Explain why effective duration and effective convexity are the most appropriate measures of interest rate risk for bonds with embedded options.

LOS 59.b: Calculate the percentage price change of a bond for a specified change in benchmark yield, given the bond's effective duration and convexity.

So far, all of our duration measures have been calculated using the YTM and prices of straight (option-free) bonds. This is straightforward because both the future cash flows and their timing are known. This is not the case with bonds that have embedded options, such as callable bonds, putable bonds, or a mortgage-backed security (MBS). Embedded options may bring about the early termination of a bond, either at the choice of the investor (for a putable bond) or at the choice of the issuer or underlying borrowers (for callable bonds and MBSs).

PROFESSOR'S NOTE

Recall that a callable bond gives the issuer the right to buy the bond back before maturity. As such, it is equivalent to a straight (option-free) bond and a short call option position. A putable bond gives the investor the right to sell the bond back to the issuer before maturity. As such, it is equivalent to a straight (option-free) bond and a long put option position.

MBSs are similar to callable bonds because mortgage borrowers have the right to prepay their loans. We will explain MBSs in detail in our reading on Mortgage-Backed Security Instrument and Market Features.

The fact that bonds with embedded options have uncertain future cash flows and redemption dates means they do not have a single well-defined yield. The yield of the bond will depend on whether the option embedded in the bond is exercised (recall that we can calculate a yield to maturity and a yield to each call date for a callable bond).

Thus, analyzing interest rate risk for bonds with embedded options is based on shifts in the *benchmark curve* (e.g., government par rates), rather than changes in the bond's own yield. This measure of price sensitivity is referred to as **effective duration** (EffDur).

Calculating effective duration is the same as calculating approximate modified duration, but we replace the change in YTM with ΔCurve, the change in the benchmark yield curve (used with a bond pricing model to generate V_- and V_+). The formula for calculating effective duration is as follows:

$$\text{effective duration} = \frac{V_- - V_+}{2V_0 \Delta\text{Curve}}$$

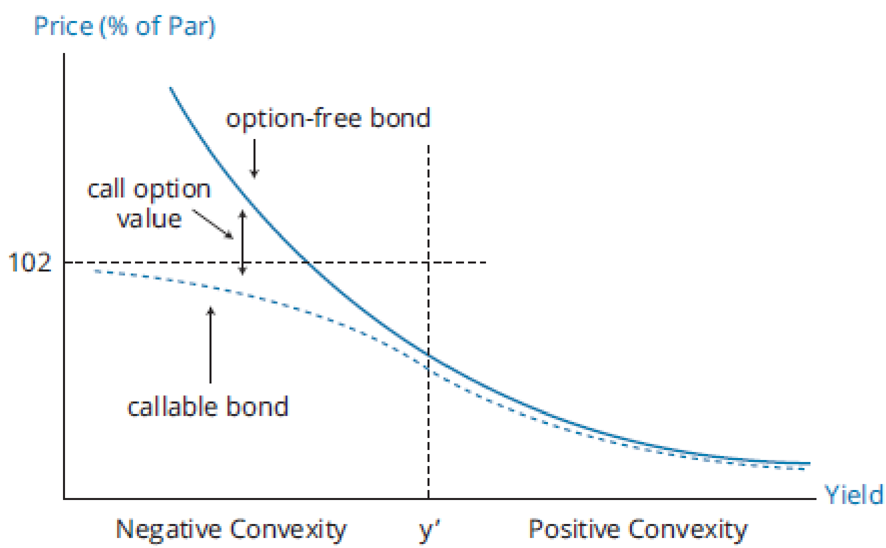
Another difference between effective duration and the methods we have discussed so far is that effective duration separates the effects of changes in benchmark yields from changes in the spread for credit and liquidity risk. Modified duration makes no distinction between changes in the benchmark yield and changes in the spread. Effective duration reflects only the sensitivity of the bond's value to changes in the benchmark yield curve and assumes all else (including spreads) remains the same.

When calculating the convexity of bonds with embedded options, we use an analogous measure, **effective convexity** (EffCon), which is once again based on changes in the benchmark curve, rather than on changes in the bond's YTM:

$$\text{effective convexity} = \frac{V_- + V_+ - 2V_0}{(\Delta\text{Curve})^2 V_0}$$

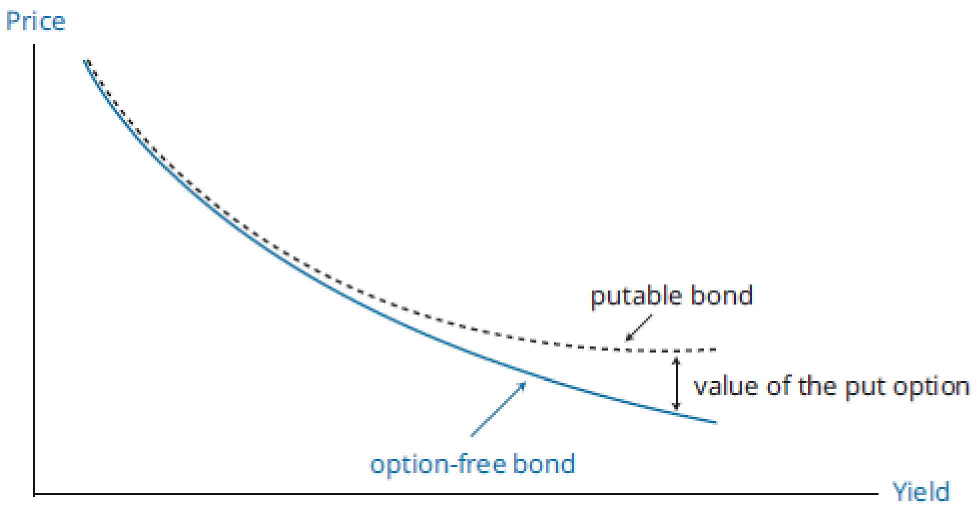
While the convexity of any option-free bond is positive, a callable bond can exhibit **negative convexity**. This is because at low yields, the call option becomes more valuable, and the call price puts an effective limit on increases in bond value, as shown in Figure 59.1. For a bond with negative convexity, the price increase that results from a decrease in YTM is *smaller* than the price decrease that results from an equal-sized increase in YTM. This means the duration of a callable bond is less than that of an equivalent option-free bond at low yields.

Figure 59.1: Price-Yield Function of Callable vs. Option-Free Bond With a Call Price of 102



A putable bond always has positive convexity. In Figure 59.2, we illustrate the price-yield relation for a putable bond. At higher yields, the put becomes more valuable, so that the value of the putable bond decreases less than that of an option-free bond as yield increases. This means the duration of a putable bond is less than that of an equivalent option-free bond at high yields.

Figure 59.2: Comparing the Price-Yield Curves for Option-Free and Putable Bonds



For an option-free bond, small differences can be observed between modified duration (with respect to ΔYTM) and effective duration (with respect to ΔCurve). This may be surprising, because it seems natural to assume that any shift in government par yield curve would automatically flow through into a similar change in the yields of risky bonds. However, in a nonflat yield curve environment, a shift in the benchmark par yield curve will generate a *nonparallel* shift in the government spot curve. If we assume that credit spreads above government spot rates remain the same, this will mean the change in the risky bond's yield will be slightly different to the original shift in government par yield curves, causing ModDur to be slightly different to EffDur.

PROFESSOR'S NOTE

Recall that bond yields are a weighted average of the spot rates that apply to the individual cash flows of the bond. When we shift the government par yield curve to calculate EffDur, we must also change the government spot rate curve that generates these yields. Not all spot rates have an equal weight in calculating a particular par yield; hence, spot rates change by different amounts (the spot curve undergoes a nonparallel shift). This nonparallel shift in spots means that the yields of risky bonds, assumed to offer a constant spread above government spot rates, may not move exactly in line with the original ΔCurve shift. This is a fairly technical point, so for the exam just understand that for option-free bonds, ModDur and EffDur are not exactly the same for a given ΔCurve unless the yield curve is flat.

We can estimate the expected price change for a bond with respect to an expected change in the yield curve using EffDur and EffCon in the same way we use modified duration and convexity with respect to ΔYTM:

$$\text{change in full bond price} = -\text{EffDur} \times (\Delta\text{Curve}) + \frac{1}{2} \times \text{EffCon} \times (\Delta\text{Curve})^2$$

Unlike modified duration and convexity, effective duration and convexity do not necessarily provide better estimates of bond prices for smaller changes in yield. This is because for bonds with embedded options, considerations other than the level of government rates determine whether the option is likely to be exercised (e.g., the level of credit spreads on a corporate bond or the amount of principal outstanding on a mortgage).

LOS 59.c: Define key rate duration and describe its use to measure price sensitivity of fixed-income instruments to benchmark yield curve changes.

Recall that effective duration is an adequate measure of bond price risk only for parallel shifts in the benchmark yield curve. The impact of nonparallel shifts can be measured using a concept known as **key rate duration**. A key rate duration, also known as a **partial duration**, is defined as the sensitivity of the value of a bond or portfolio to changes in the benchmark yield for a *specific* maturity, holding other yields constant. The sum of a bond's key rate durations equals its effective duration.

Key rate duration is particularly useful for measuring **shaping risk**, defined as the effect of a nonparallel shift in the yield curve on a bond portfolio. We can use the key rate duration for each maturity to compute the effect on the portfolio of a yield change at that maturity. The effect on the overall portfolio is the sum of these individual effects.

The key rate duration of a cash flow in a portfolio is the cash flow's modified duration multiplied by its weight in the portfolio. This key rate duration can then be used to assess the impact of a nonparallel shift in the yield curve, as demonstrated in the following example.

EXAMPLE: Key rate duration

A portfolio has equally weighted investments in a 5-year zero-coupon bond yielding 5% and a 10-year bond yielding 6%. Yields are quoted on an annual coupon basis. What would be the performance of the portfolio if 5-year yields increase by 50 basis points and 10-year yields decrease by 25 basis points?

Answer:

Recall that modified duration is equal to Macaulay duration divided by (1 + periodic yield). Also recall that the Macaulay duration of a single cash flow is equal to its maturity.

For the 5-year cash flow: ModDur = 5 / (1.05) = 4.762

The 5-year key rate duration is ModDur × weight in portfolio = 4.762 × 0.5 = 2.381.

The impact of a 50 bp increase in the 5-year yield is, therefore, −2.381 × 0.0050 = −0.0119, or −1.19%.

For the 10-year cash flow: ModDur = 10 / (1.06) = 9.434

The 10-year key rate duration is ModDur × weight in portfolio = 9.434 × 0.5 = 4.717.

The impact of a 25 bp decrease in the 10-year yield is, therefore, −4.717 × −0.0025 = 0.0118, or 1.18%.

Overall, the portfolio value will change by −1.19% + 1.18% = −0.01%. The portfolio value is expected to remain roughly unchanged in response to this nonparallel shift in yields.

LOS 59.d: Describe the difference between empirical duration and analytical duration.

The duration measures we have introduced so far, based on mathematical analysis, are often referred to as **analytical durations**. A different approach is to estimate **empirical durations** using the actual observed historical relationship between benchmark yield changes and bond price changes.

When we estimate corporate bond durations based on a shift in the benchmark (government) yield curve, we implicitly assume that the credit spread for the corporate bond remains unchanged (i.e., changes in the benchmark yield curve and a bond's yield spread are uncorrelated). When this assumption is not justified, estimates of empirical duration, based on the actual relationship between changes in the benchmark yield curve and bond values, may be more appropriate.

An example of such a situation is an increase in market uncertainty during which investor demand shifts sharply toward bonds with low credit risk (a "flight to quality"). Yields on government bonds decrease, but credit spreads increase at the same time. As a result, government bond prices increase, but corporate bond prices increase by less or possibly even fall. For a corporate bond portfolio, an estimate of empirical duration that accounts for this effect would be lower (i.e., less price response to a decrease in benchmark yields) than an estimate of analytical duration would indicate. An analytical estimate of the duration of a portfolio consisting primarily of government debt securities, in this case, would still be appropriate, while an empirically derived estimate of duration would be more appropriate for a portfolio comprising corporate bonds (risky credits).

MODULE QUIZ 59.1

1. Effective duration is more appropriate than modified duration for estimating interest rate risk for bonds with embedded options because these bonds:
   A. tend to have greater credit risk than option-free bonds.
   B. exhibit high convexity that makes modified duration less accurate.
   C. have uncertain cash flows that depend on the path of interest rate changes.
2. When an embedded option has significant value, relative to an equivalent option-free bond, the effective duration of a bond with an embedded option will *most likely* be:
   A. lower.
   B. the same.
   C. higher.
3. Which of the following bonds is *most likely* to exhibit negative convexity?
   A. Callable bonds in a low-yield environment.
   B. Callable bonds in a high-yield environment.

C. Putable bonds in a high-yield environment.

4. A bond portfolio manager who wants to estimate the sensitivity of the portfolio's value to changes in the 5-year yield only should use a(n):
   A. key rate duration.
   B. Macaulay duration.
   C. effective duration.
5. Assume that a bond has an effective duration of 10.5 and a convexity of 97.3. Using both of these measures, the estimated percentage change in price for this bond, in response to a decline in the yield curve of 200 basis points, is *closest* to:
   A. 19.05%.
   B. 22.95%.
   C. 24.89%.

KEY CONCEPTS

LOS 59.a

Because bonds with embedded options have uncertain cash flows, they do not have a single well-defined yield. Therefore, effective duration and effective convexity must be calculated with respect to shifts in the benchmark curve rather than the bond's yield for bonds with embedded options.

Effective duration is a linear estimate of the percentage change in a bond's price that would result from a 1% change in the benchmark yield curve:

$$\text{effective duration} = \frac{V_- - V_+}{2V_0 \Delta\text{Curve}}$$

$$\text{effective convexity} = \frac{V_- + V_+ - 2V_0}{(\Delta\text{Curve})^2 V_0}$$

Callable bonds and MBS may exhibit negative convexity at low yields.

LOS 59.b

The expected price change for a bond with respect to an expected ΔCurve is estimated as follows:

$$\text{change in full bond price} = -\text{EffDur} \times (\Delta\text{Curve}) + \frac{1}{2} \times \text{EffCon} \times (\Delta\text{Curve})^2$$

LOS 59.c

Key rate duration is a measure of the price sensitivity of a bond or a bond portfolio to a change in yield for a specific maturity while other yields remain the same. Key rate durations of a bond or portfolio can be used to estimate price sensitivity to changes in the shape of the yield curve.

LOS 59.d

Macaulay, modified, and effective duration are examples of analytical duration. Empirical duration is estimated from historical data using models. Empirical duration may be lower than analytical duration in interest rate environments where the assumptions underlying analytical duration may not hold, such as for credit-risky bonds in a flight-to-quality scenario.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 59.1

1. **C** Because bonds with embedded options have cash flows that are uncertain and depend on future interest rates, effective duration must be used. (LOS 59.a)
2. **A** Embedded options decrease the duration of the bond relative to an equivalent option-free bond when the option has significant value. (LOS 59.b)
3. **A** Negative convexity is exhibited only by callable bonds in a low-yield environment where the call price creates a ceiling on the price of the callable bond, causing the rate of price rises to decrease as yields fall. Putable bonds never exhibit negative convexity. (LOS 59.b)
4. **A** Key rate duration refers to the sensitivity of a bond or portfolio value to a change in one specific maturity yield. (LOS 59.c)
5. **B** Total estimated price change = (duration effect + convexity effect) = $\{[-10.5 \times (-0.02)] + [1/2 \times 97.3 \times (-0.02)^2]\} \times 100 = 21.0\% + 1.95\% = 22.95\%$

   (LOS 59.b)

READING 60

CREDIT RISK

MODULE 60.1: CREDIT RISK

Video covering this content is available online.

LOS 60.a: Describe credit risk and its components, probability of default and loss given default.

Credit risk is the risk associated with losses to fixed income investors stemming from the failure of a borrower to make payment of interest or principal (referred to as to servicing their debt). When a borrower fails to service their debt, they are said to be in **default**.

The key drivers of credit risk are either specific to the borrower (bottom up) or relate to general economic conditions (top down). These are often referred to as the *C*s of credit analysis.

Bottom-up credit analysis factors are as follows:

- **Capacity.** The borrower's ability to make their debt payments on time.
- **Capital.** Other resources available to the borrower that reduce reliance on debt.
- **Collateral.** The value of assets pledged to provide the lender with security in the event of default.
- **Covenants.** The legal terms and conditions the borrowers and lenders agree to as part of a bond issue.
- **Character.** The borrower's integrity (e.g., management for a corporate bond) and their commitment to make payments under their debt obligations.

Top-down credit analysis factors are as follows:

- **Conditions.** The general economic environment that affects all borrowers' ability to make payments on their debt.
- **Country.** The geopolitical environment, legal system, and political system that apply to the debt.
- **Currency.** Foreign exchange fluctuations and their impact on a borrower's ability to service foreign-denominated debt.

At its core, credit risk stems from the possibility that the borrower's *sources of repayments* will not provide enough cash to service their debt.

The sources of repayment for a debt issuer depend on the nature of the borrower and the specifics of the loan or bond issue. **Secured corporate debt** is backed primarily by the operating cash flows and investments of the business plus cash flows generated from collateral specifically pledged as security for the debt. **Unsecured corporate debt** is only backed by the operating cash flows and investments of the issuer (as well as secondary sources of cash flow such as asset sales, divestures of subsidiaries, or additional debt/equity issuance). Credit risk for a corporate issuer may come from poor economic and market conditions, increased competition, low profitability, or having excessive debt levels.

Sovereign debt is backed by tax revenue, tariffs, and other fees charged by the government issuer. Secondary sources of cash flow include additional debt issuance and sale of public assets (privatizations). Credit risk for a sovereign issuer may stem from poor economic conditions and political uncertainty, fiscal deficits (tax revenue being less than government spending), and high debt levels relative to the size of the economy.

Credit analysts should distinguish between an issuer being *illiquid*, or unable to raise cash to service debt, and being *insolvent*, where the assets of an issuer fall below the value of its debt. An illiquid issuer may not necessarily be insolvent, but could still default.

When default occurs, clauses written into a bond indenture are important. A **cross-default clause** means that a default on one bond issue causes a default on all issues. A **pari passu clause** means all bonds of a certain type rank equally in the default process. When pari passu and cross-default provisions exist on unsecured debt, a default on one issue implies that all holders of unsecured claims have access to the general assets of the issuer to satisfy their obligations. For secured debtholders, such clauses mean default on any obligation of the issuer will grant access to the general assets of the company and to the assets pledged as collateral for the debt. Only when the value of the pledged assets falls below the amount of pari passu secured debt will a secured bond investor suffer credit losses.

Measuring Credit Risk

Credit risk is measured by assessing the **expected loss** from a debt investment in the event of default:

expected loss = probability of default × loss given default

Probability of default is the probability that a borrower fails to pay interest or repay principal when due. The probability is typically expressed on an annualized basis. **Loss given default** is the loss an investor will suffer if the issuer defaults. This can be stated as a monetary amount or as a percentage.

A bond's expected **recovery rate** is the proportion of a claim an investor will recover if the issuer defaults. The proportion an investor will not recover, or one minus the recovery rate, is known as **loss severity**.

A debt investor's **expected exposure** or **exposure at default** is the difference between the amount the investor is owed (principal and accrued interest) and the value of the collateral available to repay the investor. Loss given default, stated as a percentage, is the product of the expected exposure and the loss severity:

LGD% = expected exposure × (1 – recovery rate)

PROFESSOR'S NOTE

Technically, loss given default is defined as a monetary amount, and the loss expressed as a rate is defined as loss severity. However, the Level I curriculum regularly states loss given default as a rate and then uses it as a rate in examples; hence, the definition is slightly loose. Be careful to read what you are given and what you need to calculate. For clarity in our SchweserNotes, when we use loss given default as a rate, we will refer to it as LGD%.

We can use the annualized expected loss (as a percentage) as an estimate of the annualized credit spread over a risk-free benchmark that an investor should demand for facing the credit risk of the investment:

credit spread ≈ probability of default × LGD%

If the actual credit spread of the issue is higher than this estimated credit spread, the investor is more than fairly compensated for the credit risk of the investment. If the actual credit spread of a bond is less than this estimated credit spread, investors are not adequately compensated for credit risk and should avoid investing.

EXAMPLE: Expected loss and credit spreads

A bond issuer has a 3% probability of default, and one of its bond issues has a recovery rate of 75%. The bond has a 4% coupon and is currently trading at par. A government security of similar maturity yields 2.5%. Assess whether the credit spread of the bond issue is adequately compensating investors for credit risk.

Answer:

The bond is trading at par, so its coupon of 4% is also its yield. The actual credit spread of the bond is, therefore, 4% – 2.5% = 1.5%.

The estimated credit spread for the bond is its probability of default times (1 – recovery rate):

= 0.03 × (1 – 0.75)

= 0.0075, or 0.75%

Hence, the bond is providing an actual spread that is double that which is fair, meaning that bond investors are more than adequately compensated for the credit risk of the bond.

To assess the required returns from credit-risky bonds, an analyst will need to estimate the probability of default for the issuer and the loss given default for the bond issue.

Probability of default can be assessed through quantitative metrics relating to capacity to repay. For example, a profitable company with high EBIT margin, a high interest coverage ratio (EBIT/interest), low leverage multiples (e.g., debt/EBITDA), and a high ratio of cash flow to net debt would be deemed of high credit quality (low probability of default).

Estimates of loss given default depend on the whether the bond is secured or unsecured, and the level of seniority of the bond issue in the capital structure of the issuer. More senior, secured debt will have lower losses given default than junior, unsecured debt.

Due to their financial strength, investment grade issuers have lower probability of default than high-yield issuers. However, high-yield issuers often issue secured debt with a secondary source of repayment in the event of default. As a result, high-yield debt can have lower losses given default than unsecured bonds of an investment grade issuer. The greatest risk to the investors in unsecured investment grade debt is not an increase in loss given default, but an increase in the probability of default due to deterioration in the issuer's financial situation.

PROFESSOR'S NOTE

The terms *investment grade* and *high yield* are formally defined in terms of credit ratings, which we will describe next.

LOS 60.b: Describe the uses of ratings from credit rating agencies and their limitations.

Credit rating agencies assign forward-looking ratings to both the issuers of bonds and their debt issues, based on qualitative and quantitative credit risk factors.

Uses of credit ratings include the following:

- Comparing the credit risk of issuers across industries and bond types, and assessing changing credit conditions over time.
- Assessing **credit migration risk**, the risk that a credit rating downgrade will decrease the value of the bonds and potentially trigger other contractual clauses.
- Meeting regulatory, statutory, or contractual requirements.

Figure 60.1 shows ratings scales used by Standard & Poor's, Moody's, and Fitch, three of the major credit rating agencies.

Figure 60.1: Credit Rating Categories

(a) Investment Grade Ratings		(b) Non-Investment Grade Ratings	
Moody's	Standard & Poor's, Fitch	Moody's	Standard & Poor's, Fitch*
Aaa	AAA	Ba1	BB+
Aa1	AA+	Ba2	BB
Aa2	AA	Ba3	BB−
Aa3	AA−	B1	B+
A1	A+	B2	B
A2	A	B3	B−
A3	A−	Caa1	CCC+
Baa1	BBB+	Caa2	CCC
Baa2	BBB	Caa3	CCC−
Baa3	BBB−	Ca	CC
		C	C
		C	D

*Fitch omits the use of +/− symbols for the CCC rating.

Triple A (AAA or Aaa) is the highest rating. Bonds with ratings of Baa3/BBB− or higher are considered **investment grade**. Bonds rated Ba1/BB+ or lower are considered **non-investment grade** and are often called *high-yield bonds* or *junk bonds*.

Bonds in default are rated D by Standard & Poor's and Fitch and are included in Moody's lowest rating category, C.

Relying on ratings from credit rating agencies has some risks:

1. *Credit ratings lag market pricing.* Market prices and credit spreads can change much faster than credit ratings. Additionally, two bonds with the same rating can trade at different yields because credit ratings focus on expected loss, whereas market pricing for distressed debt focuses more on default timing and expected recoveries.
2. *Some risks are difficult to assess.* Risks such as litigation, natural disasters, environmental risks, acquisitions, and equity buybacks using debt are not easily predicted, or captured in credit ratings. Agencies may take different views on the likelihood of such events, leading to **split ratings** where the same debt issue gets assigned different ratings from different agencies.
3. *Rating agencies are not perfect.* Mistakes occur from time to time. Infamously, subprime mortgage securities were assigned much higher ratings than they deserved in the lead-up to the global financial crisis of 2008–2009. Cases of corporate fraud can also lead to companies with high credit ratings suddenly defaulting.

Investors should also do their own due diligence when assessing credit risk and not rely purely on credit ratings. Investors who trade correctly in anticipation of credit rating changes will experience far superior performance to those who trade in reaction to rating changes.

LOS 60.c: Describe macroeconomic, market, and issuer-specific factors that influence the level and volatility of yield spreads.

Credit spread risk is the risk that yield spreads widen due to deteriorating conditions, causing credit-risky bond prices to decrease. This is a primary concern for investment grade bond investors because default is unlikely to occur suddenly. A more realistic concern is that spreads widen and prices fall as credit conditions worsen. Credit spread risk arises from macroeconomic, issuer-specific, and market (trading related) factors.

Macroeconomic Factors

Credit risk changes largely in line with the economic cycle. In times of strong growth and high profits, the probability of default decreases, causing spreads to contract; at times of recession, the probability of default increases, causing spreads to widen.

Credit spreads for high-yield issuers may behave differently than credit spreads for investment grade issuers over a business cycle. Examples of the typical behavior of both are as follows:

- Investment grade issuers have lower yield spreads than high-yield issuers due to their lower expected loss.
- Yield spreads usually increase with maturity because the probability of default increases over longer time frames, giving rise to upward-sloping credit spread curves (plots of credit spread vs. maturity).
  - During economic contractions (recessions), high-yield and investment grade credit curves rise and flatten as the probability of a near-term default increases. The high-yield credit curve may even invert (turn downward sloping) in this stage of the economic cycle.
  - During economic expansions, high-yield and investment grade credit curves fall and steepen as the probability of a near-term default decreases. Credit curves will be lowest and most steep at the peak of the cycle.
- Across issuers, the dispersion of yield spreads for high-yield issuers is higher than for investment grade issuers.
- High-yield spreads tend to fluctuate more than investment grade spreads as economic conditions change. High-yield spreads can widen dramatically in times of crisis as investors sell riskier assets and buy safer ones in a **flight to quality**. Because high-yield issues tend to be less liquid, bid–offer spreads for high-yield debt may widen more than for investment grade debt in times of crisis.

PROFESSOR'S NOTE
Notice that two different kinds of spread are involved here. The yield spread of a bond is the extra return over benchmark risk-free yields. A bid–offer spread is the difference between the prices at which a bond dealer is willing to buy or sell a bond. Pay attention to which spread an exam question is referring, particularly when the component of yield spread relating to liquidity risk is identified through analyzing the size of bid–offer spreads.

It is clear that owning high-yield bonds is riskier than holding investment grade bonds from a credit spread risk perspective because spreads are more volatile for high-yield issuers. The incentive to do so is the greater yield spread offered by high-yield debt. Other incentives for exposure to this higher credit spread risk include the following:

- *Diversification*. High-yield bond prices have low or even negative correlation with investment grade bonds, so they can diversify a fixed-income portfolio.
- *Capital appreciation*. The larger spread changes for high-yield issues produce larger price gains during economic recoveries compared to investment grade issues.
- *Equity-like returns.* According to some empirical data, high-yield debt offers equity-like returns with lower volatility than equity markets.

Other systematic factors that can drive yield spreads higher include the following:

- Increasing regulations of broker-dealers and market makers in corporate bonds have increased the cost of funding bond positions.
- Funding stresses in markets may increase risk aversion.
- Heavy new issuance of debt into bond markets might not be met by increased demand.

Issuer-Specific Factors

As noted previously, the financial performance of the issuer will have a significant impact on the yield spread level and volatility on their debt. Investors often compare an issuer's yield spread to the average yield spread offered by bonds of a similar credit rating to assess issuer-specific concerns. For an issuer with problems servicing its debt, yield spreads will be wider than the average for the issuer's credit rating.

Market Factors

Market liquidity risk relates to the transaction costs of trading a bond. It can be assessed through analyzing the bid–offer spreads of market makers in a bond. The bid is the price at which investors can sell bonds, while the offer is the price at which investors can buy. A wider bid–offer spread implies higher costs of trading to investors and indicates higher market liquidity risk.

Generally, issuers with more debt outstanding or with higher credit ratings will have more actively traded bonds (and therefore narrower bid–offer spreads) with less market liquidity risk. Market liquidity risk is higher for less actively traded bonds, for issuers with lower credit quality, and for issuers with less debt outstanding in bond markets.

Bid–offer spreads can widen substantially for high-yield issuers during times of financial stress as market liquidity falls dramatically. This can lead to a general increase in risk aversion, which may cause wider bid–offer spreads to spill over to investment grade issuers.

The bid–offer spreads of market makers can be used to isolate the component of the yield spread that is due to liquidity risk. This is done by calculating the yield at the bid and offer prices, and assuming this difference is reflected in the yield spread of the bond as compensation for liquidity risk. The remaining component of the yield spread is assumed to be related to the credit risk of the issuer.

EXAMPLE: Decomposing yield spread into liquidity and credit spreads

A 10-year bond has an annual coupon of 5% and a bid–offer spread of 99.5/100.5. The benchmark 10-year yield is 3%. Decompose the yield spread into liquidity spread and credit spread.

Answer:

First, we assess the yield spread of the bond based on the midprice quote, which is the average of the bid and offer prices.

midprice quote = (99.5 + 100.5) / 2 = 100

At a price of par, a bond's yield is its coupon; hence, the bond is yielding 5% at its midprice quote.

The yield spread of the bond over the benchmark yield is 5% – 3% = 2%.

Yield at the bid price:

N = 10; PV = –99.5; PMT = 5; FV = 100; CPT→I/Y = 5.065

Yield at the offer price:

N = 10; PV = –100.5; PMT = 5; FV = 100; CPT→ I/Y = 4.935

The liquidity spread of the bond is the bid yield minus the offer yield:

liquidity spread = 5.065% – 4.935% = 0.13%

The credit component of the yield spread is therefore 2% – 0.13% = 1.87%.

We have seen that the sensitivity of a bond's price to a change in yield can be estimated using the bond's duration and convexity. We can also use these measures to estimate the price impact of a change in spread, simply by replacing the yield change (ΔYTM) with the spread change (ΔSpread):

$$\text{change in full price of bond} = -\text{ModDur}\,(\Delta\text{Spread}) + \frac{1}{2}\,\text{convexity}(\Delta\text{Spread})^2$$

MODULE QUIZ 60.1

1. The two components of expected loss are:
   A. default risk and yield spread.
   B. probability of default and loss severity.
   C. loss severity and yield spread.
2. Expected loss can decrease with an increase in a bond's:
   A. probability of default.
   B. loss severity.
   C. recovery rate.
3. Which of the following factors in credit analysis is *least likely* a top-down factor?
   A. Capital.

B. Conditions.
C. Currency.

4. Higher credit risk is indicated by a higher:
   A. cash flow/debt ratio.
   B. debt/EBITDA ratio.
   C. EBITDA/interest expense ratio.
5. Compared to other firms in the same industry, an issuer with a credit rating of AAA is *most likely* to have a lower:
   A. cash flow/debt ratio.
   B. operating margin.
   C. debt/capital ratio.
6. Credit spreads tend to widen as:
   A. the credit cycle improves.
   B. economic conditions worsen.
   C. broker-dealers become more willing to provide capital.
7. Compared to shorter-duration bonds, longer-duration bonds:
   A. have smaller bid-ask spreads.
   B. are less sensitive to credit spreads.
   C. have less certainty regarding future creditworthiness.

KEY CONCEPTS

LOS 60.a

Credit risk refers to the possibility that a borrower fails to make the scheduled interest payments or return of principal.

Bottom-up credit analysis factors include capacity, capital, collateral, character, and covenants.

Top-down credit analysis factors include country, conditions, and currency.

Credit risk is measured through expected loss, which is the product of the probability of default and the loss given default.

Expected loss as a percentage is an estimate of the credit spread investors should demand:

credit spread ≈ POD × LGD%

Loss given default expressed as a rate is also called loss severity, and equals one minus the recovery rate.

A profitable company with high EBIT margin, high interest coverage ratio, low leverage multiples, and high cash flow to net debt would be deemed of high credit quality with a low probability of default.

More senior, secured debt will have a smaller loss given default than junior, unsecured debt.

LOS 60.b

Credit ratings reflect a debt issuer or debt issue’s overall creditworthiness and assess the likelihood that debt will be fully paid back.

Ratings of BBB-/Baa3 and above are classed as investment grade and of lower credit risk. Ratings of BB+/Ba1 and below are deemed to be non-investment grade (high-yield) and of higher credit risk.

Investors should not rely exclusively on credit ratings from rating agencies for these reasons:

- Rating agencies cannot always judge credit risk accurately.
- Firms are subject to risk of unforeseen events that credit ratings do not reflect.
- Market prices of bonds often adjust more rapidly than credit ratings.

LOS 60.c

An issue’s yield spread over its benchmark reflects credit risk and liquidity risk.

The level and volatility of yield spreads are affected by the credit and business cycles, availability of capital from broker-dealers, the supply and demand for debt issues, and the financial performance of the bond issuer.

Yield spreads tend to narrow when the credit cycle is improving, the economy is expanding, and financial markets and investor demand for new debt issues are strong. Yield spreads tend to widen when the credit cycle, the economy, and financial markets are weakening, and in periods when the supply of new debt issues is heavy or broker-dealer capital is insufficient for market making.

The liquidity spread can be estimated as the difference between yields of a bond at bid and offer prices. The remainder of the yield spread is considered credit spread.

Given an expected change in spread, duration and convexity can be used to estimate the impact on price:

$$\text{change in full price of bond} = -\text{ModDur}\,(\Delta\text{Spread}) + \frac{1}{2}\,\text{convexity}(\Delta\text{Spread})^2$$

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 60.1

1. **B** Expected loss is composed of probability of default and loss severity. Yield spreads reflect the credit risk of a borrower, but they are a reflection of expected loss rather than a component of it. (LOS 60.a)

2. **C** An increase in the recovery rate means that the loss severity has decreased, which decreases expected loss. (LOS 60.a)

3. **A** Top-down credit analysis factors include country, conditions, and currency. Capital is a bottom-up factor relating to the reliance of the issuer on debt and the availability of other sources of funding. (LOS 60.b)

4. **B** A higher debt/EBITDA ratio is sign of higher leverage and higher credit risk. Higher cash flow/debt and EBITDA/interest expense ratios indicate lower credit risk. (LOS 60.a)

5. **C** A low debt/capital ratio is an indicator of low leverage. An issuer rated AAA is likely to have a high operating margin and a high cash flow/debt ratio compared to its industry group. (LOS 60.a)

6. **B** Credit spreads widen as economic conditions worsen. Spreads narrow as the credit cycle improves and as broker-dealers provide more capital to bond markets. (LOS 60.c)

7. **C** Longer-duration bonds usually have longer maturities and carry more uncertainty of future creditworthiness. (LOS 60.c)

READING 61

CREDIT ANALYSIS FOR GOVERNMENT ISSUERS

MODULE 61.1: CREDIT ANALYSIS FOR GOVERNMENT ISSUERS

Video covering this content is available online.

LOS 61.a: Explain special considerations when evaluating the credit of sovereign and non-sovereign government debt issuers and issues.

Sovereign Government Debt

The ability of a **sovereign debt** issuer to service its debts comes primarily from its ability to tax economic activity in its jurisdiction. Assessing the credit risk of sovereign issuers requires an analyst to evaluate the factors that provide for stable economic growth with low inflation. These factors can generally be split into five qualitative factors and three quantitative factors.

The following are five qualitative factors in sovereign creditworthiness:

1. *Institutions and policy factors* address whether a government encourages political and economic stability. Economically, this means enforcement of basic legal protections and property rights, a culture of debt repayment, transparency and consistency in data reporting, and policies that encourage business activity. Politically, this means a stable political system and peaceful coexistence with neighboring countries. The willingness of a government to repay debt is also important (unlike with corporate issues) because bondholders usually have no legal recourse if a government refuses to pay its debts (national governments are said to have **sovereign immunity**).
2. *Fiscal flexibility factors* relate to the government's ability to increase tax collection or decrease public spending to ensure debt service payments are made.
3. *Monetary effectiveness factors* relate to the ability of the central bank to vary the money supply and interest rates in a credible manner to encourage stable economic growth. A central bank that is independent from the government is less likely to print money to service government debts, reducing the risk of high inflation and currency weakness.
4. *Economic flexibility factors* relate to growth trends, income per capita, and diversity of sources for economic growth.

5. *External status factors* relate to the standing of a country's currency in international markets. Countries with **reserve currencies**, which are widely held as foreign exchange reserves at central banks across the world, have more ability to issue debt to foreign investors in their domestic currency and maintain larger budget deficits and higher levels of debt. Geopolitical risks relating to international conflict are also a consideration.

The following are three quantitative factors in sovereign creditworthiness:

1. *Fiscal strength* is measured by low debt burden ratios (debt to GDP and debt to revenue) and low interest-to-GDP or interest-to-revenue ratios (which measure debt affordability).
2. *Economic growth and stability* is measured by high real GDP growth, large real economy size, high per-capita GDP, and low volatility of real GDP growth.
3. *External stability* is measured by high foreign exchange reserves to GDP, high foreign exchange reserves to external debt, low long-term external debt to GDP, and low near-term external debt (due in the next 12 months) relative to GDP. Foreign exchange reserves are usually built up by a country that exports more than it imports (has a current account surplus). If exports are concentrated in a specific commodity, sovereign credit risk becomes aligned with the price of that commodity.

Non-Sovereign Government Debt

Issuers of **non-sovereign government debt** include the following:

- *Agencies.* These quasi-government entities are established to carry out a particular government-sponsored role, such as infrastructure development and operation. Backed by law, and with implicit government support, credit ratings for agency debt issues are usually similar to the relevant sovereign debt rating.
- *Government sector banks or financing institutions.* These financial intermediaries are set up with a specific government-sponsored mission, such as issuing green bonds to raise finance for projects designed to mitigate climate change. Similar to agencies, implied government support means that credit ratings are similar to the sovereign entity.
- *Supranational issuers.* Entities such as the World Bank and the Development Bank of Latin America are set up by groups of sovereign governments to carry out projects with varied missions, such as alleviating poverty or encouraging sustainable economic growth. Credit ratings for these issues depend on the implicit support of the governments and global development institutions that sponsor them.
- *Regional governments.* These include provinces, states, and local governments (the debt issues of which are referred to as **municipal bonds** in the United States). Most regional government bonds can be classified as general obligation bonds or revenue bonds. **General obligation (GO) bonds** are unsecured bonds backed by the full faith and credit of the issuing non-sovereign government entity, which is to say they are supported by its taxing power. **Revenue bonds** are issued to finance specific projects, such as airports, toll bridges, hospitals, and power generation facilities.

Unlike sovereigns, regional governments cannot use monetary policy to service their debt and usually must balance their operating budgets. Municipal governments' ability to service their general obligation debt depends ultimately on the local economy (i.e., the tax base). Revenue bonds often have higher credit risk than GO bonds because the project is the sole source of funds to service the debt.

Analysis of revenue bonds uses techniques similar to those for analyzing corporate bonds, with a focus on the cash flows generated by the project and the ability of the issuer to service their debt as measured by the debt-service coverage ratio (revenue after operating costs relative to interest and principal repayments required).

MODULE QUIZ 61.1

1. One key difference between sovereign bonds and municipal bonds is that sovereign issuers:
   A. can print money.
   B. have government taxing power.
   C. are affected by economic conditions.
2. All else equal, a sovereign debt issuer with higher credit quality will *most likely* have a higher:
   A. debt burden ratio.
   B. debt affordability ratio.
   C. foreign exchange reserve ratio.

KEY CONCEPTS

LOS 61.a

The five qualitative factors relevant for assessing sovereign debt are (1) government institutions and policy, (2) fiscal flexibility, (3) monetary effectiveness, (4) economic flexibility, and (5) external status.

The three quantitative factors relevant for assessing sovereign debt are (1) fiscal strength, (2) economic growth and stability, and (3) external stability.

Non-sovereign government debt issuers include agencies, government sector banks, supranational entities, and regional governments. Major types of regional government bonds include general obligation (GO) bonds, backed by tax-raising powers, and revenue bonds, issued to fund a specific project.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 61.1

1. **A** Sovereign entities can print money to repay debt, while municipal borrowers cannot. Both sovereign and municipal entities have taxing powers, and both are affected by economic conditions. (LOS 61.a)

2. **C** A foreign exchange reserve ratio looks at the level of foreign exchange reserves relative to external debt. A high ratio implies higher credit quality on an external stability basis. Debt burden ratios measure the level of sovereign debt relative to GDP or tax revenue. As such, a higher ratio indicates a more indebted nation and therefore lower credit quality due to less fiscal strength. Debt affordability ratios compare interest payments to GDP or revenue. When these ratios are high, this suggests lower credit quality on a fiscal strength basis. (LOS 61.a)

READING 62

CREDIT ANALYSIS FOR CORPORATE ISSUERS

MODULE 62.1: CREDIT ANALYSIS FOR CORPORATE ISSUERS

Video covering this content is available online.

LOS 62.a: Describe the qualitative and quantitative factors used to evaluate a corporate borrower's creditworthiness.

An analyst will use both qualitative and quantitative factors when evaluating the likelihood and impact of default by a corporate bond issuer.

Qualitative Factors

Qualitative factors include an issuer's business model, the degree of competition in its industry, its business risk, and the quality of its corporate governance.

Business model. A corporate issuer with high credit quality will have a business model with stable and predictable cash flows. For longer-term debt issues, a credit analyst should consider both the existing business model and any long-term changes to it that the issuer will need to make to remain competitive. Changes in the business model will increase business risk.

Industry competition. Less intensive competition is favorable for an issuer's credit quality. As with the business model, analysts need to consider any change in the competitive landscape over the long term.

Business risk. High-credit-quality issuers have low risk of unexpected deviations from expected revenues and margins. Business risk can originate from issuer-specific, industry-specific, or external sources.

Corporate governance. An issuer with high credit quality should have sufficient processes in place relating to the fair and legal treatment of debtholders. Specific concerns include debt covenants and accounting policies.

- *Covenants*. For unsecured investment-grade issuers, it is likely that covenants are primarily affirmative, relating to compliance with rules and laws, maintenance of company assets, and paying taxes. Analysts must assess the potential for management to issue additional debt that would dilute the claims of existing debtholders. High-yield issuers are likely to have negative covenants, restricting the issuer's ability to pay dividends or issue further debt, in addition to affirmative covenants. Here, analysts need to assess the past actions of management for evidence of preferential treatment of equity investors over debt investors, particularly if this led to credit rating downgrades (e.g., a debt-financed stock buyback program).

- *Accounting policies*. While evidence of fraud is an obvious concern, the use of aggressive accounting policies that accelerate revenue recognition, significant use of off-balance-sheet financing, a heavy preference for capitalizing spending rather than immediate expensing, and frequently changing auditors or the chief financial officer are also warning signs that the character of management may hurt the creditworthiness of the issuer.

Quantitative Factors

Quantitative modeling of the future performance of corporate issuers involves estimating future financial statements and cash flows of the issuer to identify key factors driving their probability of default and loss given default, and how these are likely to change over the economic cycle. While investors in unsecured investment-grade debt are likely to be primarily concerned about the probability of default increasing, investors in secured high-yield debt are also concerned about loss given default, due to the higher probability of default for high-yield debt.

Quantitative analysis can be performed on a top-down or bottom-up basis, or both. *Top-down* inputs relate to the macroeconomic cycle, the size of the industry and potential market share, and event risk related to potential external shocks. *Bottom-up* inputs relate to issuer-specific factors driving revenue, costs, balance sheet assets and liabilities, and future cash flows. A *hybrid* approach considers both top-down and bottom-up factors.

All else equal, companies are deemed to be of higher credit quality if the issuer has:

- Strong operating profits and recurring revenues
- Low levels of leverage and less reliance on debt in the capital structure
- High coverage of debt service payments with periodic income
- High levels of liquidity to meet short-term debt payments

LOS 62.b: Calculate and interpret financial ratios used in credit analysis.

Credit analysts calculate ratios to assess the creditworthiness of a company, to find trends over time, and to compare companies to industry averages and peers. Common ratios relate to profitability, coverage, and leverage.

Some key terms that are commonly used in calculating ratios are as follows:

- **Earnings before interest, taxes, depreciation, and amortization (EBITDA)**. EBITDA is a commonly used measure that is calculated as operating income plus depreciation and amortization. A drawback to using this measure for credit analysis is that it does not adjust for capital expenditures and changes in working capital, which are necessary uses of funds for a going concern. Cash needed for these uses is not available to debtholders.

- **Cash flow from operating activities (CFO)**. CFO is net cash paid or received in the continuing operations of the business. It is calculated as net income plus noncash charges minus increase in working capital. CFO is disclosed by companies in their cash flow statements.
- **Funds from operations (FFO)**. FFO is net income from continuing operations plus depreciation, amortization, deferred taxes, and noncash items. FFO is similar to CFO, except that FFO excludes changes in working capital.
- **Free cash flow (FCF)**. FCF is CFO minus fixed asset expenditures plus net interest expense. It represents the discretionary cash flow of a company because it could be paid to providers of financing after all the obligations of the company have been met.
- **Retained cash flow (RCF)**. RCF is operating cash flow minus dividends. Analysts may define operating cash as CFO, FFO, or another preferred measure.

Common credit analysis ratios are summarized in Figure 62.1.

Figure 62.1: Financial Ratios for Corporate Credit Analysis

Ratio Type	Ratio Name	Calculation	Indication of Higher Credit Quality
Profitability	EBIT margin	EBIT / revenue	Higher ratio
Coverage	EBIT to interest expense	EBIT / interest expense	Higher ratio
Leverage	Debt to EBITDA	Debt / EBITDA	Lower ratio
Leverage	RCF to net debt	RCF / (debt – cash and marketable securities)	Higher ratio

EXAMPLE: **Credit analysis based on ratios**

An analyst is assessing the credit quality of York, Inc., and Zale, Inc. Selected financial information appears in the following table.

	York, Inc.	Zale, Inc.
Revenue	$2,200,000	$11,000,000
Depreciation and amortization	$220,000	$900,000
Earnings before interest and taxes	$550,000	$2,250,000
Cash flow from operations	$300,000	$850,000
Interest expense	$40,000	$160,000
Total debt	$1,900,000	$2,700,000
Cash and marketable securities	$500,000	$1,000,000
Dividends	$30,000	$200,000

Using profitability, coverage, and leverage ratios, explain how the analyst should evaluate the relative creditworthiness of York and Zale.

Answer:

Profitability ratios based on these data are as follows:

EBIT margin = EBIT / revenue:

York: $550,000 / $2,200,000 = 25%

Zale: $2,250,000 / $11,000,000 = 20.5%

York has higher EBIT margin, so from a profitability perspective, it has higher credit quality than Zale.

Coverage ratios based on these data are as follows:

EBIT / interest:

York: $550,000 / $40,000 = 13.8×

Zale: $2,250,000 / $160,000 = 14.1×

York has a slightly lower interest coverage ratio than Zale, suggesting slightly lower credit quality. The difference is small, though, and both companies can comfortably meet their interest payments from EBIT.

Leverage ratios based on these data are as follows:

Debt / EBITDA:

York: $1,900,000 / ($550,000 + $220,000) = 2.5×

Zale: $2,700,000 / ($2,250,000 + $900,000) = 0.9×

York is more leveraged than Zale, suggesting a lower credit quality for York.

RCF / net debt:

York: ($300,000 – $30,000) / ($1,900,000 – $500,000) = 19%

Zale: ($850,000 – $200,000) / ($2,700,000 – $1,000,000) = 38%

Zale's retained cash flow (using CFO as operating cash) relative to its net debt level is greater than York. This, too, suggests a lower credit quality for York relative to Zale.

Overall, the picture is mixed. Relative to Zale, York is a more profitable company, suggesting a higher credit rating—though it relies more on debt in its capital structure, which suggests a lower credit rating. Both companies report similarly strong coverage ratios.

LOS 62.c: Describe the seniority rankings of debt, secured versus unsecured debt and the priority of claims in bankruptcy, and their impact on credit ratings.

Each different type of bond of a particular issuer is ranked according to a **priority of claims** in the event of a default. A bond's position in the priority of claims to the issuer's assets and cash flows is referred to as its **seniority ranking**.

Debt can be either **secured debt** or **unsecured debt**. Secured debt is backed by collateral, which can be sold to recover funds for bond investors in the event of default by the issuer. Unsecured debt represents a general claim to the issuer's assets and cash flows. Secured debt has a higher priority of claims than unsecured debt.

Secured debt can be further distinguished as *first lien* (where a specific asset is pledged) or *first mortgage* (where a specific property is pledged), *senior secured (second lien)*, or *junior secured* debt. Unsecured debt is further divided into *senior*, *junior*, and *subordinated* gradations. The highest rank of unsecured debt is senior unsecured. Subordinated debt ranks below other unsecured debt.

The general seniority rankings for debt repayment priority are the following:

1. First lien/mortgage
2. Senior secured (second lien)
3. Junior secured
4. Senior unsecured
5. Senior subordinated
6. Subordinated
7. Junior subordinated

All debt within the same category is said to rank **pari passu**, or have the same priority of claims. All senior secured debtholders, for example, are treated alike in a corporate bankruptcy. Any senior secured claims that are not met by the value of collateral upon which they are secured will automatically rank pari passu with senior unsecured claims in the bankruptcy process.

Recovery rates are the highest for debt with the highest priority of claims and decrease with each lower rank of seniority. The lower the seniority ranking of a bond, the higher its credit risk.

In a default or reorganization, senior lenders have claims on the assets before junior lenders and equity holders. A strict priority of claims, however, is not always applied in practice. Although in theory the priority of claims is absolute, in many cases, lower-priority debtholders (and even equity investors) may get paid even if senior debtholders are not paid in full in order to accelerate the bankruptcy process. Bankruptcies can be costly and take a long time to settle, during which the value of a company's assets could deteriorate due to loss of customers and key employees, while legal expenses mount.

Credit rating agencies rate both the issuer (i.e., the company issuing the bonds) and the debt issues, or the bonds themselves. Issuer credit ratings are called **corporate family ratings (CFRs)**, and are typically based on their senior unsecured debt, while issue-specific ratings are called **corporate credit ratings (CCRs)**.

The ratings of a firm's individual bonds can differ from its corporate (issuer) rating. The seniority and covenants (including collateral pledged) of an individual bond issue are the primary determinants of differences between an issuer's rating and the ratings of its individual bond issues. The assignment of individual issue ratings that are higher or lower than that of the issuer is referred to as **notching**.

Another example of a factor that rating agencies consider when notching an issue credit rating is **structural subordination**. In a holding company structure, both the parent company and the subsidiaries may have outstanding debt. A subsidiary's debt covenants may restrict the transfer of cash or assets "upstream" to the parent company before the subsidiary's debt is serviced. In such a case, even though the parent company's bonds are not junior to the subsidiary's bonds, the subsidiary's bonds have a priority claim to the subsidiary's cash flows. Thus, the parent company's bonds are effectively subordinated to the subsidiary's bonds with respect to the subsidiary's cash flows.

Notching is less common for highly rated issuers than for lower-rated issuers. For firms with high overall credit ratings, differences in expected recovery rates among a firm's individual bonds are less important, so their bonds might not be notched at all. For firms with higher probabilities of default (lower ratings), differences in expected recovery rates among a firm's bonds are more significant. For this reason, notching is more likely for issues with lower creditworthiness in general.

MODULE QUIZ 62.1

1. Which of the following scenarios is *most likely* to occur as a result of a corporate issuer moving from issuing unsecured debt to secured debt?
   A. The issuer is able to access debt markets that were previously unavailable to them.
   B. The market yield on the debt will increase.
   C. The issuer needs to include fewer covenants in their bond indentures.
2. The absolute priority of claims in a bankruptcy might be violated because:
   A. of the pari passu principle.
   B. creditors negotiate a different outcome.
   C. available funds must be distributed equally among creditors.
3. Notching is *best* described as a difference between a(n):
   A. issuer credit rating and an issue credit rating.
   B. company credit rating and an industry average credit rating.
   C. investment-grade credit rating and a non-investment-grade credit rating.
4. Higher credit risk is indicated by a higher:
   A. RCF/net debt ratio.
   B. debt/EBITDA ratio.
   C. EBIT/interest expense ratio.

KEY CONCEPTS

LOS 62.a

Qualitative factors that imply a corporate issuer has high creditworthiness include having a stable business model, being in an industry with low levels of competition, having low business risk, and having adequate corporate governance.

Quantitative factors that imply a corporate issuer has a high creditworthiness include strong profitability and recurring revenues, low leverage, high coverage ratios, and high levels of liquidity.

LOS 62.b

Credit analysts use profitability, leverage, and coverage ratios to assess debt issuers' capacity:

- Profitability can be measured by EBIT margin (EBIT / revenue).
- Coverage can be measured by EBIT to interest expense.
- Leverage ratios include debt to EBITDA and retained cash flow to net debt.

LOS 62.c

Corporate debt is ranked by seniority or priority of claims. Secured debt is a direct claim on specific firm assets and has priority over unsecured debt. Secured or unsecured debt may be further ranked as senior or subordinated. Priority of claims may be summarized as follows:

1. First lien/mortgage
2. Senior secured (second lien)
3. Junior secured
4. Senior unsecured
5. Senior subordinated
6. Subordinated
7. Junior subordinated

Issuer credit ratings, or corporate family ratings (CFRs), reflect a debt issuer's overall creditworthiness and typically apply to a firm's senior unsecured debt.

Issue credit ratings, or corporate credit ratings, reflect the credit risk of a specific debt issue. Notching refers to adjusting an issue credit rating upward or downward from the issuer credit rating.

For a specific debt issue, secured collateral implies lower credit risk compared to unsecured debt, and higher seniority implies lower credit risk compared to lower seniority.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 62.1

1. **A** By offering secured debt, the issuer may attract investments from investors that would have otherwise considered the unsecured bond for the issuer to be too risky. It is likely that the security will decrease the cost of borrowing for the issuer. It is also likely that secured debt will have more covenants stating the legal rights that lenders have over the collateral pledged as security for the issue. (LOS 62.a)

2. **B** A negotiated bankruptcy settlement does not always follow the absolute priority of claims. (LOS 62.c)

3. **A** Notching refers to the credit rating agency practice of distinguishing between the credit rating of an issuer (generally for its senior unsecured debt) and the credit rating of particular debt issues from that issuer, which may differ from the issuer rating because of provisions such as seniority. (LOS 62.c)

4. **B** A higher debt/EBITDA ratio is a sign of higher leverage and higher credit risk. Higher RCF/net debt and EBITDA/interest expense ratios indicate lower credit risk. (LOS 62.b)

READING 63

FIXED-INCOME SECURITIZATION

MODULE 63.1: FIXED-INCOME SECURITIZATION

Video covering this content is available online.

LOS 63.a: Explain benefits of securitization for issuers, investors, economies, and financial markets.

The **securitization** process involves the following steps:

Step 1: A bank making loans or a corporation extending credit to customers (referred to as the **originator**) creates a pool of debt-based assets.

Step 2: The pool of assets (referred to as the collateral) is sold to a separate legal entity, referred to as a **special purpose entity (SPE)**.

Step 3: The SPE issues fixed-income securities (referred to as asset-backed securities, or ABSs) supported by the cash flows from the collateral (i.e., the borrowers making repayments on their loans). These ABSs are purchased by investors, such as pension funds or fixed-income funds, that deem the risk/reward of the underlying collateral to be attractive.

Securitization connects the owners of capital (investors) with those that require capital (the borrowers in the collateral pool) and removes the originating bank or corporation from the intermediation process.

PROFESSOR'S NOTE

Care must be taken with the use of the word *issuer*, as the Level I curriculum applies it two different ways. In this LOS, the curriculum uses the term *issuer* to refer to the banks and corporations that act as *originators* in the securitization process in Step 1. In a securitization, the actual issuer of the ABS is the special purpose entity in Step 2. If you are asked about the "advantages of securitization to issuers," you should assume the question is asking you about the advantages to the originator. However, a general reference to the issuer in a securitization should be assumed to refer to the SPE.

Benefits of securitization to issuers (the originating bank/corporation) are as follows:

- *Increased business activity*. By securitizing loans, banks are able to lend more than they could if they had to finance the loans through their own balance sheet (i.e., by raising more deposits or other liabilities). When a loan portfolio is securitized, the bank receives the proceeds, which can then be used to make more loans.

- *Improved profitability*. The originating bank or corporation can charge fees for originating the initial transaction that creates the collateral (e.g., making the mortgage loan in the first place) and for selling the collateral to the SPE.
- *Lower capital reserves for banks*. By selling loans to the SPE, an originating bank removes credit risk from its balance sheet, thereby reducing the capital reserves that regulators require the bank to hold. This allows the bank to allocate more funds to profitable activities such as lending or other investments.
- *Improved liquidity*. Banks can use securitization to sell illiquid loan portfolios, thereby operating more efficiently from a risk/return perspective.

Benefits of securitization to investors are as follows:

- *Tailored risk and return*. Securitization allows issuers to create securities with risk/return profiles that align with the needs of investors. As an example, an investor with a long investment horizon can invest in a portfolio of long-term mortgage loans at acceptable levels of risk and earn returns higher than those of long-dated Treasuries.
- *Access*. By investing in ABSs, investors are able to access the collateral pool without having the specialized resources and expertise necessary to provide loan origination and loan servicing functions.
- *Liquidity*. ABSs are liquid securities that can be sold to other investors more easily than the underlying collateral, which allows investors to react more quickly to changes in market conditions than they could if they held the loans directly.

Benefits of securitization to economies and financial markets are as follows:

- *Decreased liquidity risk*. ABSs are more liquid than the underlying collateral. Hence, securitization improves liquidity in financial markets.
- *Improved market efficiency*. The greater liquidity of ABSs than the underlying collateral allows investors to set equilibrium prices, which makes the market more efficient (i.e., more reflective of current investor opinion).
- *Lower financing costs for originators*. Securitization can provide a source of finance for originators that is lower than the cost of issuing debt or equity directly to investors.
- *Lower leverage for originators*. Securitization allows originators to grow their business without having to increase debt on their balance sheets.

The risks to investors in ABSs are twofold:

- The cash flows from the collateral to the ABS investors are uncertain and can vary in timing and size (e.g., mortgage borrowers may prepay their mortgages at a rate that is different to what was expected).
- The credit risk of the collateral is passed through to investors in the ABS. Systemic buildup of credit risk in ABSs can create risks for the financial system, as shown by the financial crisis of 2007–2009.

LOS 63.b: Describe securitization, including the parties and the roles they play.

We can illustrate the basic structure of a securitization transaction with this simplified, fictitious example of Fred Motor Company.

Fred Motor Company (Fred) sells most of its cars on retail sales installment contracts (i.e., auto loans). The customers buy the automobiles, and Fred loans the customers the money for the purchase (i.e., Fred *originates* the loans) secured on the autos and receives principal and interest payments on the loans until they mature. Fred is also the *servicer* of the loans (i.e., collects principal and interest payments, sends out delinquency notices, and repossesses and disposes of autos if customers do not make timely payments) through a subsidiary established by Fred to perform financial services.

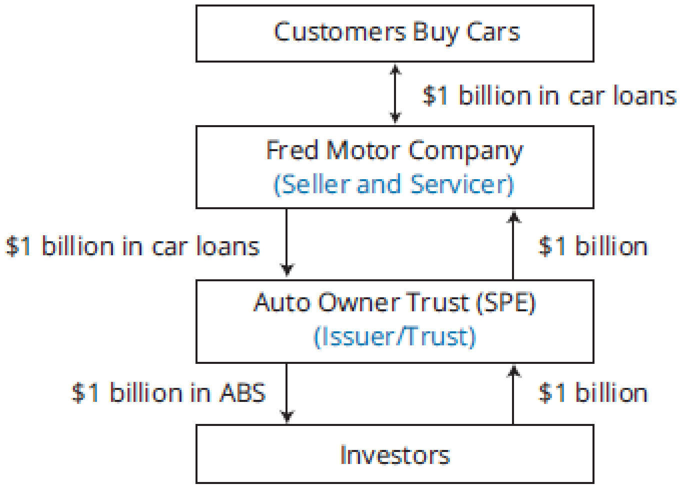
Fred has 50,000 auto loans totaling $1 billion that it would like to remove from its balance sheet and use the proceeds to make more auto loans. It accomplishes this by selling the loan portfolio to an SPE called Auto Loan Trust for $1 billion (Fred is called the *seller* or *depositor*). The SPE, which is set up for the specific purpose of buying these auto loans and selling ABSs, is referred to as the *trust* or the *issuer.* The SPE then sells ABSs to investors. The loan portfolio is the collateral supporting the ABS because the cash flows from the loans are the source of the funds to make the promised payments to ABS investors. An SPE is sometimes also called a special purpose company or special purpose vehicle (SPV). The SPE is a separate legal entity from Fred.

Let's review the parties to this transaction and their functions:

- The seller or depositor (Fred) originates the auto loans and sells the portfolio of loans to Auto Loan Trust, the SPE.
- The issuer/trust (Auto Loan Trust) is the SPE that buys the loans from the seller and issues ABSs to investors.
- The servicer (Fred) services the loans.
- In this case, the seller and the servicer are the same entity (Fred Motor Company), but that is not always the case.

The structure of this securitization transaction is illustrated in Figure 63.1.

Figure 63.1: Structure of Fred Motor Company Asset Securitization



Subsequent to the initial transaction, the principal and interest payments on the original loans are allocated to pay servicing fees to the servicer and principal and interest payments to the owners of the ABSs. A trustee is also appointed to oversee the safekeeping of collateral and cash flows due to the ABS investors and provide information to ABS holders (known as a **disinterested trustee** because they have no other interest in the structure).

Because the SPE is a separate legal entity from Fred, a decline in the financial position of Fred does *not* affect the value of the claims of ABS owners to the cash flows from the trust collateral owned by the SPE. This is referred to as the SPE being **bankruptcy remote** from the originator. This also means that the buyers of the ABS have no claim on other assets of Fred—only on the collateral sold to the SPE. If Fred had instead issued corporate bonds to finance more auto loans, the bondholders would be subject to the financial risks of Fred.

Outside of the bond indenture and covenants, important documents involved in the securitization process include the following:

- The purchase agreement, which describes the terms of the purchase of the collateral by the SPE from the seller
- The prospectus, which describes the terms of the securitization with respect to fees made to servicers and other administrators and how cash flows from the collateral are distributed to ABS investors

MODULE QUIZ 63.1

1. Economic benefits of securitization *least likely* include:
   A. reducing excessive lending by banks.
   B. reducing funding costs for firms that securitize assets.
   C. increasing the liquidity of the underlying financial assets.
2. In a securitization, the issuer of asset-backed securities is *best* described as the:
   A. special purpose entity.
   B. seller.

C. servicer.

KEY CONCEPTS

LOS 63.a

Benefits of securitization to the originators of the collateral include:

- Increased business activity through re-lending the proceeds
- Improved profitability from fees for originating and arranging the sale of collateral
- Lower capital reserves after removing the collateral from their balance sheets
- Increased liquidity of the underlying collateral

Benefits of securitization to ABS investors include:

- Risk and return tailored to the requirements of the investor
- Access to collateral that investors would have difficulty accessing directly
- Greater liquidity than the underlying collateral

Benefits of securitization to economies and financial markets include:

- Decreased liquidity risk, because ABSs can be traded more easily than the underlying collateral
- Improved market efficiency, because increased trading helps markets trade at equilibrium prices
- Lower financing costs and leverage for originators

Risks to ABS investors include uncertain size and timing of cash flows and credit risk of the collateral.

LOS 63.b

Parties to a securitization are a seller of financial assets, an SPE, and a servicer:

- The seller is the firm that is raising funds through the securitization.
- An SPE is an entity independent of the seller. The SPE buys financial assets from the seller and issues ABSs supported by these financial assets.
- The servicer carries out collections and other responsibilities related to the financial assets. The servicer may be the same entity as the seller, but does not have to be.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 63.1

1. **A** Companies that securitize loans they hold as assets receive cash with which they can make additional loans. The primary benefits of securitization to the economy include reducing firms' funding costs and increasing the liquidity of the financial assets that are securitized. (LOS 63.a)

2. **A** ABSs are issued by a special purpose entity (SPE), which is an entity created for that specific purpose. In a securitization, the firm that is securitizing financial assets is described as the seller because it sells the assets to the SPE. The servicer is the entity that deals with collections on the securitized assets. (LOS 63.b)

READING 64

ASSET-BACKED SECURITY (ABS) INSTRUMENT AND MARKET FEATURES

MODULE 64.1: ASSET-BACKED SECURITY (ABS) INSTRUMENT AND MARKET FEATURES

Video covering this content is available online.

LOS 64.a: Describe characteristics and risks of covered bonds and how they differ from other asset-backed securities.

Covered bonds are senior debt obligations of financial institutions that are similar to ABSs. However, the underlying assets (the cover pool), while segregated from other assets of the issuer, remain on the balance sheet of the issuing corporation (i.e., no SPE is created). Covered bonds are issued primarily by European, Asian, and Australian banks, and the cover pool typically consists of mortgage loans (though other types of assets can be used).

In the event of issuer default, covered bond investors have the **dual recourse** of claims on both the cover pool and, in contrast to a securitization involving an SPE, claims over other assets of the issuers that have not been pledged as collateral for other debt (referred to as unencumbered assets). To mitigate credit risk faced by covered bond investors, the mortgages that make up the cover pool are subject to upper limits on loan-to-value ratios, and the value of the collateral is usually higher than the face value of covered bonds issued (referred to as overcollateralization). The cover pool is monitored by a third party to ensure adherence to these conditions. These credit enhancements, along with dual recourse, result in covered bonds generally having lower yields than comparable ABSs.

Because the cover pool remains on the balance sheet of the issuer, the issuer will not benefit from any reduction in required capital reserves that would occur under a securitization.

Unlike an ABS, in which the pool of assets is fixed at issuance, a covered bond requires the issuer to replace or augment nonperforming or prepaid assets in the cover pool so that it always provides for the covered bond’s promised interest and principal payments. Covered bonds typically are not structured with credit tranching.

Covered bonds may have different provisions in case their issuer defaults. A **hard-bullet covered bond** is in default if the issuer fails to make a scheduled payment, leading to the acceleration of payments to covered bondholders. A **soft-bullet covered bond** may postpone the originally scheduled maturity date by as much as a year, should a payment on the covered bond be missed—effectively postponing default and associated payment acceleration. A **conditional pass-through covered bond** converts to a pass-through bond on the maturity date if any payments remain due, meaning that any payments subsequently recovered on the cover pool are passed through to investors.

LOS 64.b: Describe typical credit enhancement structures used in securitizations.

Internal credit enhancements of ABSs are features of the structure designed to mitigate the credit risk faced by investors due to defaults in the collateral pool. They take three main forms: overcollateralization, excess spread, and subordination (or credit tranching).

Overcollateralization occurs when the value of the collateral exceeds the face value of the ABS. For example, if the value of the collateral is $600 million and the face value of the ABS issued is $500 million, then there is $100 million overcollateralization. The collateral could experience default of up to 100 / 600 = 16.7% of value before investors in the ABS begin to suffer credit losses.

An **excess spread** feature builds up reserves in the ABS structure by earning higher income on the collateral than the coupon promised to ABS investors. This income can then be used to absorb credit losses in the collateral.

With **credit tranching** (also called **subordination**), the ABS is structured with multiple classes of securities (referred to as **tranches**), each with a different priority of claims to the cash flows of the collateral. Tranches ranked as subordinated absorb credit losses first (up to their principal values), thereby providing protection to senior tranches against credit losses. The level of protection for the senior tranche increases with the proportion of subordinated bonds in the structure.

Let's look at an example to illustrate how a senior/subordinated structure redistributes the credit risk compared to a single-class structure. Consider an ABS with the following bond classes:

Tranche Name	Face Value ($)	Interest Rate
Tranche A senior notes	300,000,000	MRR + 0.5%
Tranche B subordinated notes	80,000,000	MRR + 1.5%
Tranche C subordinated notes	30,000,000	Variable
Total	410,000,000	

Tranche C is first to absorb any losses, because it is the most junior tranche, until losses exceed $30 million in principal. Being the lowest-ranking tranche, it has a residual claim to any value left over after other, more senior tranches have been paid—and for this reason, it is often referred to as the **equity tranche**. Any losses from default of the underlying assets greater than $30 million, and up to $110 million, will be absorbed by subordinated Tranche B. The senior Tranche A is protected from any credit losses of $110 million or less, and therefore it will have the highest credit rating and offer the lowest yield of the three bond classes. It is through this credit tranching, and the bankruptcy remote nature of the SPE, that senior tranches of ABSs can receive credit ratings higher than that of the originating company that sells the collateral to the SPE.

PROFESSOR'S NOTE

This subordination structure is not new to us—it's the same idea as the senior/junior debt and equity capital structure of a corporate issuer.

This structure is also called a **waterfall** structure because in liquidation, each subordinated tranche would receive only the "overflow" from the more senior tranche(s) if they are repaid their principal value in full.

As long as a tranche remains outstanding, it will receive its coupon payment. For example, say an investor purchases $10 million face value of the Tranche B notes. If the MRR is 4%, and if there are no defaults in the underlying collateral, the investor will receive an annual coupon of $10,000,000 × (0.04 + 0.015) = $550,000. If defaults in the collateral pool amount to $50 million, the first $30 million of losses will be allocated to Tranche C, while the remaining losses of $20 million will reduce the outstanding face value of the Tranche B note from $80 million to $60 million. The coupon earned by the investor in Tranche B notes, in this case, is equal to $550,000 × (60 / 80) = $412,500.

LOS 64.c: Describe types and characteristics of non-mortgage asset-backed securities, including the cash flows and risks of each type.

In addition to those backed by mortgages, there are ABSs backed by various types of financial assets including business loans, accounts receivable, or automobile loans. In fact, any asset that generates a future stream of cash flows could be used as collateral for securitization, including music royalties or franchise license payments. Each of these types of ABS has different risk characteristics, and their structures vary to some extent as well. Here, we explain the characteristics of two types: ABSs backed by credit card receivables and ABSs backed by loans for homeowners to install solar panels on their property (referred to as a residential solar ABS).

A key distinction between the debt-based assets acting as collateral for these ABSs is whether it is amortizing or nonamortizing. Recall that an amortizing loan has a principal balance that is scheduled to be paid down over the life of the loan. A nonamortizing loan has no such schedule for repayment of principal.

Credit Card ABS

Credit card receivable-backed securities are ABSs backed by pools of credit card debt owed to banks, retailers, travel and entertainment companies, and other credit card issuers.

The cash flow to a pool of credit card receivables includes finance charges (i.e., interest), membership and late payment fees, and principal repayments. Credit card receivables are nonamortizing loans; however, borrowers can choose to repay principal at their discretion. Interest rates on credit card receivables can be fixed or floating, typically subject to a cap (i.e., a maximum rate that the credit card lender can charge).

A credit card securitization structure will typically include a **lockout period** or **revolving period** during which ABS investors only receive interest and fees paid on the collateral. If the underlying credit card holders make principal payments during the lockout period, these payments are used to purchase additional credit card receivables, keeping the overall value of the pool relatively constant.

PROFESSOR'S NOTE
In our reading on mortgage-backed securities, we will discuss prepayment risk at length. Prepayment risk occurs when borrowers repay loans at a different speed to that originally anticipated by investors. During the revolving period of a credit card ABS, investors are not subject to prepayment risk because any principal payments in the underlying collateral are used to make additional loans.

Once the lockout period ends, the **amortization period** of the ABS begins, and principal payments made on the underlying collateral are passed through to security holders. Credit card ABSs typically have an early (rapid) amortization provision that provides for earlier amortization of principal when it is necessary to preserve the credit quality of the securities, akin to an acceleration of payment for a debt issuer when credit conditions worsen.

Solar ABSs

Solar ABSs are backed by loans to homeowners wishing to finance the installation of solar energy systems to reduce their energy bills. These loans are offered by specialist finance companies or the financing subsidiaries of solar energy companies.

Solar ABSs are attractive to investors focused on environmental, social, and governance (ESG) factors because, through investing in the solar ABS, they are providing funds for homeowners to switch to a renewable energy source. Solar loans themselves can be secured on the solar energy system itself or on the homeowner's property as a junior mortgage, providing extra security to ABS investors.

Internal credit enhancement methods such as overcollateralization, excess spread, or subordination are common in these structures. Solar loans are usually made to homeowners with good credit scores, who are saving on energy bills through installing the solar energy system; hence, credit risk is likely to be low. However, solar ABSs are a relatively new asset class and are yet to be tested through a full credit cycle.

Many solar ABSs have a **pre-funding period**, which allows the trust to make investments in solar-related loans for a fixed time period after raising funds through issuing the ABS. A pre-funding period allows the ABS structure to invest in a larger, more diversified pool of solar-related investments.

LOS 64.d: Describe collateralized debt obligations, including their cash flows and risks.

A **collateralized debt obligation (CDO)** is a structured security issued by an SPE for which the collateral is a pool of debt obligations. When the collateral securities are corporate and emerging market debt, they are called collateralized bond obligations (CBOs). Collateralized loan obligations (CLOs) are supported by a portfolio of leveraged bank loans. Unlike the ABSs we have discussed, CDOs do not rely solely on payments from a static collateral pool to meet obligations from issuing securities. What sets CDOs apart from regular ABSs is that CDOs have a **collateral manager** who dynamically buys and sells securities in the collateral pool to generate the cash to make the promised payments to investors.

PROFESSOR'S NOTE

Leveraged loans are senior secured bank loans made to companies that have high levels of debt already, or have a poor credit history.

CDOs issue subordinated tranches in a similar fashion to ABSs. In creating a CDO, the structure must be able to offer an attractive return on the lowest-ranked equity tranche, after accounting for the required yields on the more senior CDO debt tranches.

Before the 2007–2009 global financial crisis, CDOs were based on a wide variety of underlying collateral. Since the crisis, CDO structures have become less complex, and more stringent requirements have been placed on the quality of the collateral. Collateral today comprises mostly leveraged loans; hence, the most common form of CDO is the CLO.

Three major types of CLOs are as follows:

1. *Cash flow CLOs*: Payments to CLO investors are generated through cash flows on the underlying collateral.
2. *Market value CLOs*: Payments to CLO investors are generated through trading the market value of the underlying collateral.
3. *Synthetic CLOs*: The collateral pool exposure is generated through credit derivative contracts. In this type of CLO, the CLO trust does not take ownership of the collateral.

The collateral of a CDO is subject to a series of prespecified tests to protect CLO investors from default:

- Coverage of payment obligations to the CLO investors by cash flows from the collateral
- Overcollateralization levels for each tranche—breaches of overcollateralization limits cause cash flows to be redirected to purchase additional collateral or to pay off the senior-most tranches of the CDO
- Diversification in the collateral pool
- Limitations on the amount of CCC rated debt in the collateral pool

MODULE QUIZ 64.1

1. During the lockout period of a credit card ABS:
   A. no new receivables are added to the pool.
   B. investors do not receive interest payments.
   C. investors do not receive principal payments.
2. A debt security that is collateralized by a pool of the sovereign debt of several developing countries is *best* described as a:
   A. CLO.
   B. CBO.
   C. CMO.
3. A covered bond is *most likely* to feature:
   A. a fixed cover pool.
   B. recourse to the issuer.
   C. a special purpose entity.

KEY CONCEPTS

LOS 64.a

Covered bonds are similar to asset-backed securities, but instead of creating an SPE, the collateral (cover pool) remains on the balance sheet of the issuer. Covered bonds give bondholders recourse to the issuer as well as the asset pool, which increases the bonds' credit quality.

LOS 64.b

Internal credit enhancements of ABS include the following:

- *Overcollateralization*. The value of the collateral is greater than the face value of the ABS securities.
- *Excess spread*. Income from the collateral in excess of the payment obligations to ABS investors acts as a reserve to absorb default losses in the collateral pool.
- *Credit tranching*. Credit losses are first absorbed by the tranche with the lowest priority, and after that, by any other subordinated tranches, in order.

LOS 64.c

Credit card ABSs are backed by credit card receivables, which are nonamortizing receivables. Credit card ABSs typically have a lockout/revolving period during which only interest and fees are passed through from the collateral pool to investors, while any principal payments on the receivables are used to purchase additional receivables. Following this period, the ABSs have an amortization period where principal payments are passed through to ABS investors.

Solar ABSs are backed by loans to homeowners to finance installation of domestic solar energy equipment. Solar loans can be secured on the solar energy equipment or the homeowner's residence. Solar ABSs may be attractive to ESG investors.

LOS 64.d

Collateralized debt obligations (CDOs) are structured securities backed by a pool of debt obligations that are managed by a collateral manager. CDOs include collateralized bond obligations (CBOs) backed by corporate and emerging market debt, and collateralized loan obligations (CLOs) backed by leveraged bank loans.

Three major types of CLO are as follows:

- *Cash flow CLOs*. Payments to CLO investors are generated through cash flows on the underlying collateral.
- *Market value CLOs*. Payments to CLO investors are generated through trading the market value of the underlying collateral.
- *Synthetic CLOs*. Collateral pool exposure is generated through credit derivative contracts.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 64.1

1. **C** During the lockout period on a credit card receivables backed ABS, no principal payments are made to investors. (LOS 64.c)

2. **B** A collateralized bond obligation (CBO) is backed by an underlying pool of fixed-income securities, which may include emerging markets debt. Collateralized loan obligations (CLOs) are backed by leveraged loans. Collateralized mortgage obligations (CMOs) are backed by pools of mortgages or mortgage-backed securities. (LOS 64.d)

3. **B** Covered bonds differ from ABSs in that bondholders have recourse to the issuer as well as the cover pool. Covered bonds are not issued through special purpose entities. A covered bond issuer must maintain a dynamic cover pool, replacing any nonperforming or prepaid assets. (LOS 64.a)

READING 65

MORTGAGE-BACKED SECURITY (MBS) INSTRUMENT AND MARKET FEATURES

MODULE 65.1: MORTGAGE-BACKED SECURITY (MBS) INSTRUMENT AND MARKET FEATURES

Video covering this content is available online.

LOS 65.a: Define prepayment risk and describe time tranching structures in securitizations and their purpose.

An important characteristic of investments in mortgage-backed securities (MBSs) is their **prepayment risk**. Prepayments are principal repayments by mortgage borrowers in excess of the scheduled principal repayments for amortizing loans. In a pool of mortgages, some of the borrowers are likely to prepay, typically because they sell their homes or refinance their mortgages.

MBS valuation is based on an assumed prepayment rate for the underlying mortgages. Prepayment risk is the risk that prepayment speeds turn out to be *different to the expectations* of MBS investors when they purchased the MBS.

The risk that prepayments will be slower than expected, leading to MBS investors waiting longer than originally anticipated for their cash flows, is called **extension risk**. The risk that prepayments will be faster than expected, leading to cash flows arriving sooner than expected, is called **contraction risk**.

A key driver of prepayment speeds is the prevailing level of interest rates. When interest rates decrease, borrowers often refinance their mortgages at lower rates. This will cause the original higher-rate mortgages to be repaid early, increasing prepayment speeds and leading to contraction in the average life of an MBS. This is bad for MBS investors for two reasons:

- They receive cash flows sooner than expected in a low-rate environment and face lower reinvestment returns.
- Because the prices of MBS reflect expectations for prepayments in low-rate environments, they will not rise as much in response to decreasing interest rates as other fixed-income instruments that do not have an embedded prepayment option.

PROFESSOR'S NOTE

MBSs are like callable bonds, where the borrower has the right to repay the loan early, which leads to negative convexity for prices at low yields (i.e., prices rise at a slower rate as yields fall).

When interest rates increase, borrowers' prepayment speeds will be slower than expected because refinancing activity will slow, leading to extension in the average life of an MBS. This is also bad for MBS investors because cash flows will be discounted by more periods at a higher discount rate.

One way to reapportion the prepayment risk inherent in the underlying mortgage pool is to use **time tranching** in the MBS structure. An MBS with time tranching will have different bond classes with different maturities. Contraction and extension risk still exist with this structure, but the risks are redistributed to some extent among the tranches. The tranches that mature first offer investors protection against extension risk. Tranches with longer maturities provide relatively more protection against contraction risk. We will describe one method of time tranching, called sequential pay tranching, later in this reading.

LOS 65.b: Describe fundamental features of residential mortgage loans that are securitized.

A **residential mortgage loan** is a loan for which the collateral that underlies the loan is residential real estate. If the borrower defaults on the loan, the lender has a legal claim to the collateral property (referred to as a first lien), whereby they can take possession of the property and sell it to recover losses (a process called foreclosure).

PROFESSOR'S NOTE

MBSs backed by residential mortgages are called residential mortgage-backed securities (RMBSs). These residential mortgages are the focus of this LOS. Commercial mortgages, which relate to investments in properties to generate income rather than to provide a home for the borrower, as well as their related commercial mortgage-backed securities, are discussed later in the reading.

Common features of residential mortgage loans include the following:

- *Prepayment penalties*. A prepayment penalty is an additional payment that must be made by borrowers to compensate lenders if principal is prepaid when interest rates decline. Common in Europe, but rare in the United States, these penalties are designed to reduce prepayment risk for lenders.
- *Recourse/nonrecourse loans*. Nonrecourse loans only have the specified property as collateral. With recourse loans, the lender also has a claim against other assets of the borrower for any amount by which the foreclosure falls short of the payments outstanding on a defaulting loan. When the property value falls below the outstanding mortgage balance (a situation known as *underwater mortgages* or *negative equity*), borrowers with nonrecourse loans are more likely to strategically default, preferring to face foreclosure and a reduction in their credit score rather than continue to make

payments on a loan exceeding the value of the property. In Europe, most residential mortgages are recourse loans. In the United States, the nature of the loans varies by state, but most loans are nonrecourse.

Loan-to-Value and Debt-to-Income Ratios

A key measure of default risk for a mortgage loan is its **loan-to-value ratio (LTV)**, the percentage of the value of the collateral real estate that is loaned to the borrower. The lower the LTV, the higher the borrower's equity in the property. For a lender, loans with lower LTVs are less risky because the borrower has more to lose in the event of default (so is less likely to default). Also, if the property value is high compared to the loan amount, the lender is more likely to recover the amount loaned if the borrower defaults and the lender repossesses and sells the property.

Another key measure is the borrower's **debt-to-income ratio (DTI)**, which measures the monthly debt payments of the individual as a percentage of their monthly pretax gross income. A borrower with a lower DTI is deemed of lower risk to default.

For example, a borrower wishing to take out a $300,000 mortgage on a $400,000 property will have an LTV of $300,000 / $400,000 = 75%.

If the mortgage has an annual interest rate of 6%, is to be repaid monthly over 25 years, and the borrower's annual pretax gross income is $80,000, then we can calculate the DTI as follows.

First, calculate the constant monthly payment required to service the mortgage:

$$\mathrm{N} = 25 \times 12 = 300;\ \mathrm{I/Y} = 6 / 12 = 0.5;\ \mathrm{PV} = 300{,}000;\ \mathrm{FV} = 0;\ \mathrm{CPT} \rightarrow \mathrm{PMT} = \$1{,}932.90$$

Second, calculate the monthly pretax gross income of the borrower as $80,000 / 12 = $6,667.

Then, calculate DTI as $1,932.90 / $6,667 = 29%.

In the United States, mortgages made to borrowers with good credit, low LTV, and low DTI are termed **prime loans**. Mortgages to borrowers of lower credit quality, with higher DTI, higher LTV, or that have a lower-priority claim to the collateral in event of default, are termed **subprime loans**.

Agency and Non-Agency RMBSs

In the United States, a distinction is made between *agency and non-agency* RMBSs.

Agency RMBSs are either guaranteed by the government or guaranteed by a government-sponsored enterprise (GSE), which are companies created by the government. Because GSEs are technically distinct from the government, the securities guaranteed by GSEs do not carry the full faith and credit of the government—only that of the GSE that provides the guarantee. Mortgages need to meet minimum underwriting standards to qualify as collateral for an agency RMBS.

Non-agency RMBSs are issued by private entities such as banks and have no government or GSE guarantee. Non-agency RMBSs typically include credit enhancements through external insurance, letters of credit, tranching, and private guarantees. Non-agency RMBSs are often cited as a catalyst for the global financial crisis of 2007–2009, when investment-grade senior tranches backed by subprime mortgages suffered large losses due to significant defaults in the underlying collateral. Issuance of non-agency RMBSs effectively ceased after the credit crisis due to changes in regulation.

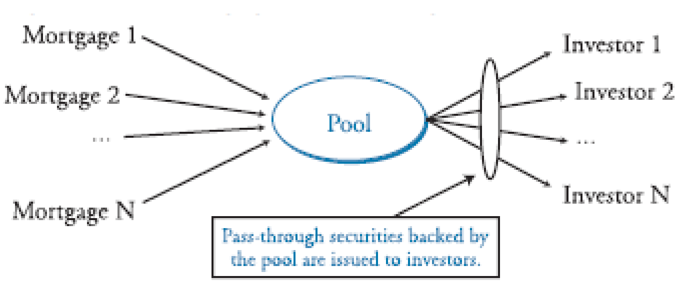
LOS 65.c: Describe types and characteristics of residential mortgage-backed securities, including mortgage pass-through securities and collateralized mortgage obligations, and explain the cash flows and risks for each type.

A **mortgage pass-through security** represents a claim on the cash flows from a pool of mortgages, net of administration fees. Any number of mortgages may be used to form the pool, and any mortgage included in the pool is referred to as a **securitized mortgage**.

The mortgages in the pool typically have different maturities and different mortgage rates. The **weighted average maturity (WAM)** of the pool is equal to the weighted average of the final maturities of all the mortgages in the pool, weighted by each mortgage's outstanding principal balance as a proportion of the total outstanding principal value of all the mortgages in the pool. The **weighted average coupon (WAC)** of the pool is the weighted average of the interest rates of all the mortgages in the pool (weighted in the same way as WAM).

Investors in mortgage pass-through securities receive the monthly cash flows generated by the underlying pool of mortgages, less any servicing and guarantee/insurance fees. The fees account for the fact that **pass-through rates** (i.e., the coupon rate on the MBS, also called its *net interest* or *net coupon*) are less than the WAC of the underlying mortgage pool.

Figure 65.1: Mortgage Pass-Through Cash Flow



EXAMPLE: WAM and WAC

An MBS contains the three mortgages A, B, and C, with details displayed in the following table.

Mortgage	Interest Rate	Beginning Balance (000 USD)	Current Balance (000 USD)	Original Term (Months)	Months to Maturity
A	2.6%	100	90	240	210
B	1.0%	200	72	300	100
C	5.4%	300	247	360	280

Calculate the WAM and the WAC for this MBS.

Answer:

Both the WAM and the WAC are calculated using the current balance of the mortgages as weights. Given that the sum of current balances is 90 + 72 + 247 = 409, the WAM is calculated as follows:

$$\text{WAM} = 210\left(\frac{90}{409}\right) + 100\left(\frac{72}{409}\right) + 280\left(\frac{247}{409}\right) = 233 \text{ months}$$

The WAC is calculated as follows:

$$\text{WAC} = 2.6\%\left(\frac{90}{409}\right) + 1.0\%\left(\frac{72}{409}\right) + 5.4\%\left(\frac{247}{409}\right) = 4.0\%$$

Collateralized Mortgage Obligations

Collateralized mortgage obligations (CMOs) are securities that are collateralized by pass-through MBSs and pools of mortgages. Each CMO has multiple bond classes (CMO tranches) that have different exposures to prepayment risk. The total prepayment risk of the underlying RMBS is not changed, but is reapportioned among the various CMO tranches.

Institutional investors have different tolerances for prepayment risk. Some are primarily concerned with extension risk, while others may want to minimize exposure to contraction risk. By partitioning and distributing the cash flows generated by RMBSs into different risk packages to better match investor preferences, CMOs increase the potential market for securitized mortgages, and perhaps reduce funding costs as a result.

Common CMO structures include sequential pay tranches, planned amortization class tranches, support tranches, and floating-rate tranches.

In a **sequential pay CMO**, principal payments for the collateral flow to tranches in a prespecified order. Once the first tranche has been fully paid, principal from the underlying collateral will flow to the next tranche in the structure.

As an example, consider a simple CMO with two tranches. Both tranches receive interest payments at a specified coupon rate, but principal payments (both scheduled payments and prepayments) are paid to Tranche 1 (the “short” tranche) until its principal is paid off. Principal payments then flow to Tranche 2 until its principal is paid off.

Contraction and extension risk still exist with this structure, but they have been redistributed to some extent between the two tranches. The short tranche, which matures first, offers investors relatively more protection against extension risk. The other tranche provides relatively more protection against contraction risk.

Investors with preferences for shorter-term securities will prefer tranches paid back sooner because they will have a lower expected average life than other tranches that ranked lower in the order for receiving principal payments.

Other CMO structures include the following:

- **Z-tranches.** A Z-tranche (also called an *accrual* or *accretion* bond) is a CMO tranche that receives no interest payments during a specified accrual period. Instead, during the accrual period, the tranche accrues interest as extra principal. For example, if a Z-tranche with a coupon rate of 5% has $100 of principal outstanding at the start of the accrual period, then at the end of the first period, the principal amount of the Z-tranche would be increased to $105 (rather than Z-tranche holders receiving a $5 cash interest payment). Once the accrual payment has ended, interest and principal payments on the Z-tranche begin. A Z-tranche is typically the lowest-ranking tranche in a CMO structure.
- **Principal-only (PO) securities.** These securities pay only principal from the collateral pool; hence, they are effectively zero-coupon securities. Decreasing interest rates and increasing prepayment speeds benefit PO tranche holders because their return comes purely from the difference between the price paid and the repayment of principal. The sooner the principal is repaid, the higher the annualized return to PO security investors.
- **Interest-only (IO) securities.** These securities pay only interest from the collateral pool. Decreasing interest rates and increasing prepayment speeds harm IO tranche holders because their return comes purely from coupon payments on outstanding principal. The sooner the principal is repaid, the fewer coupon payments IO security investors receive.
- **Floating-rate tranches.** These tranches pay a coupon that is linked to a variable market reference rate, often subject to a cap and a floor. Tranches can also be structured as inverse floaters, where the coupon paid rises (falls) as interest rates fall (rise).
- **Residual tranches.** Residual tranches of CMOs rank junior to all other tranches, similar to the equity tranche of an ABS.
- **Planned amortization class (PAC) tranches and support tranches.** A PAC tranche is structured to make predictable payments to investors as long as prepayment speeds remain within a certain range. If prepayment speeds increase, the support tranche receives the principal repayments in excess of those specifically allocated to the PAC tranches. Conversely, prepayment speeds decrease, principal repayments to the support tranche are curtailed so the scheduled PAC payments can be made. In this way, both contraction and extension risk are reduced for PAC tranche investors. However, this protection is limited by the range of prepayment speeds under which the support tranche can operate. Should speeds move outside this range, the PAC tranche will not receive payments in line with its planned amortization schedule.

LOS 65.d: Describe characteristics and risks of commercial mortgage-backed securities.

Commercial mortgage-backed securities (CMBSs) are backed by pools of commercial mortgages on income-producing real estate, typically in the form of apartments (multifamily), industrial property (e.g., warehouses), shopping centers, office buildings, health care facilities (e.g., senior housing), and hotels.

CMBSs typically have fewer mortgages in the collateral pool than RMBSs—in some cases, a CMBS can even be backed by a single mortgage on a high-value, well-known property in a major city. Hence, there is less diversification against default risk. CMBSs can be backed by mortgages from an individual lender, or multiple commercial mortgages by one borrower. CMBSs are common in the United States, where CMBS coupons are fixed. CMBS volumes are increasing in Europe, where they typically have floating coupons.

An important difference between residential and commercial MBSs is the obligations of the borrowers of the underlying loans. Residential MBS loans are repaid by the owners or occupiers of the property; commercial MBS loans are repaid by real estate investors who, in turn, rely on tenants (usually businesses) of the property and their customers to provide the cash flow to repay the mortgage loan. The regular income from the collateral of a CMBS is referred to as the weighted average proceeds from the mortgages (WAMP), which plays the same role as WAC for an RMBS.

For these reasons, the analysis of CMBSs focuses on the credit risk of the property and not the credit risk of the borrower. Analysts focus on two key ratios to assess credit risk.

1. The **debt service coverage ratio (DSCR**, or **DSC ratio)** is a basic cash flow coverage ratio of the amount of cash flow from a commercial property available to make debt service payments, compared to the required debt service cost:

   $$\text{debt service coverage ratio} = \frac{\text{net operating income}}{\text{debt service}}$$

   Net operating income is calculated as rental income less cash operating expenses and a noncash replacement reserve that represents the depreciation of the property over time. This ratio indicates greater protection to the lender when it is higher.

2. The **loan-to-value ratio (LTV)** compares the loan amount on the property to its current fair market or appraisal value:

   $$\text{LTV} = \frac{\text{current mortgage amount}}{\text{current appraised value}}$$

   This is the same ratio we discussed in the context of residential mortgages. As was the case there, a higher LTV indicates higher default risk.

Two differences between CMBS and the RMBS we discussed earlier are call protection and balloon maturity provisions.

Call protection is equivalent to prepayment protection (i.e., restrictions on the early return of principal through prepayments). CMBSs provide call protection in two ways:

loan-level call protection provided by the terms of the individual mortgages, and call protection provided by the CMBS structure.

There are several means of creating **loan-level call protection**:

- *Prepayment lockout.* For a specific time period (typically, two to five years), the borrower is prohibited from prepaying the mortgage loan.
- *Prepayment penalty points.* A penalty fee expressed in points may be charged to borrowers who prepay mortgage principal. Each point is 1% of the principal amount prepaid.
- *Defeasance.* The borrower uses payments in excess of scheduled loan payments to purchase a portfolio of government securities that is sufficient to make the remaining scheduled principal and interest payments on the loan. This protects the lender from prepayments (because they continue to expect to receive the same payments as under the original loan schedule), and it allows the borrower to remove the lender's lien on the property, should they wish to sell the property before the end of the mortgage term.

To create **CMBS-level call protection**, loan pools can be subject to sequential pay tranching in a similar fashion to the process used for CMOs.

Commercial mortgages are typically not fully amortized, meaning that at the end of the loan term, some principal remains outstanding that needs to be paid. This is referred to as a **balloon payment**. If the borrower is unable to arrange refinancing to make this payment, the borrower is in default. This possibility is called **balloon risk**. In this case, the lender might extend the term of the loan during a "workout period" under modified terms. Because balloon risk entails extending the term of the loan, it is a form of extension risk for CMBS investors.

MODULE QUIZ 65.1

1. The risk that mortgage prepayments will occur more slowly than expected is *best* characterized as:
   A. default risk.
   B. extension risk.
   C. contraction risk.
2. A sequential pay security is structured with three tranches: A, B, and C. Tranche A receives principal first, followed by Tranche B, and finally Tranche C. An investor concerned about extension risk would *most likely* prefer:
   A. Tranche A.
   B. Tranche B.
   C. Tranche C.
3. For investors in commercial mortgage-backed securities, balloon risk in commercial mortgages results in:
   A. call risk.
   B. extension risk.
   C. contraction risk.

KEY CONCEPTS

LOS 65.a

Prepayment risk refers to uncertainty about the timing of the principal cash flows from an MBS. Contraction risk is the risk that loan principal will be repaid more rapidly than expected, typically when interest rates have decreased. Extension risk is the risk that loan principal will be repaid more slowly than expected, typically when interest rates have increased.

Time tranching can be used to distribute prepayment risk across the tranches of an MBS.

LOS 65.b

The loan-to-value ratio (LTV) indicates the percentage of the value of the real estate collateral that is loaned. Lower LTVs indicate less credit risk.

The debt-to-income ratio (DTI) indicates the size of the monthly debt payments of the borrower relative to their monthly pretax gross income. Lower DTIs indicate lower credit risk.

Agency residential mortgage-backed securities (RMBSs) are guaranteed and issued by the federal government or a government-sponsored enterprise. Mortgages that back agency RMBS must meet certain minimum credit quality standards. Non-agency RMBSs are issued by private companies and may be backed by riskier subprime loans.

LOS 65.c

Key characteristics of RMBS pass-through securities include the pass-through rate (the coupon rate on the RMBS) and the weighted average maturity (WAM) and weighted average coupon (WAC) of the underlying pool of mortgages.

Collateralized mortgage obligations (CMOs) are collateralized by RMBSs or pools of mortgages. CMOs are structured with tranches that have different exposures to prepayment risks.

In a sequential pay CMO, all scheduled principal payments and prepayments are paid to each tranche in sequence until that tranche is paid off. The first tranche to be paid principal has the most contraction risk, and the last tranche to be paid principal has the most extension risk.

A planned amortization class CMO has PAC tranches that receive predictable cash flows as long as the prepayment rate remains within a predetermined range, and support tranches that have more contraction risk and more extension risk than the PAC tranches.

Other types of CMO tranches include Z-tranches, principal-only tranches, interest-only tranches, floating-rate tranches, and residual tranches.

LOS 65.d

Commercial mortgage-backed securities (CMBSs) are backed by mortgages on income-producing real estate properties. Because commercial mortgages are nonrecourse loans, analysis of CMBSs focuses on credit risk of the properties. CMBSs are structured in tranches with credit losses absorbed by the lowest-priority tranches in sequence.

Call (prepayment) protection in CMBSs includes loan-level call protection such as prepayment lockout periods, defeasance, prepayment penalty points, and CMBS-level call protection provided by lower-priority tranches.

CMBS loans are more likely to be partially amortizing than residential loans, leading to balloon risk.

Ratios used to analyze the credit risk of a commercial mortgage include the debt service coverage ratio and the loan-to-value ratio.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 65.1

1. **B** Extension risk is the risk that prepayments will be slower than expected. Contraction risk is the risk that prepayments will be faster than expected. (LOS 65.a)

2. **A** An investor concerned about extension risk would prefer to purchase a tranche that is paid back sooner than other tranches; hence, the investor would prefer Tranche A. (LOS 65.c)

3. **B** Balloon risk is the possibility that a commercial mortgage borrower will not be able to refinance the principal that is due at the maturity date of the mortgage. This results in a default that is typically resolved by extending the term of the loan during a workout period. Thus, balloon risk is a source of extension risk for CMBS investors. (LOS 65.d)

TOPIC QUIZ: FIXED INCOME

You have now finished the Fixed Income topic section. Please log into your Schweser online dashboard and take the Topic Quiz on this section. The Topic Quiz provides immediate feedback on how effective your study has been for this material. Questions are more exam-like than typical Module Quiz or QBank questions; a score of less than 70% indicates that your study likely needs improvement. These tests are best taken timed; allow 1.5 minutes per question.

READING 66

DERIVATIVE INSTRUMENT AND DERIVATIVE MARKET FEATURES

MODULE 66.1: DERIVATIVES MARKETS

Video covering this content is available online.

LOS 66.a: Define a derivative and describe basic features of a derivative instrument.

A **derivative** is a security that *derives* its value from the value of another security or a variable (such as an interest rate or stock index value) at some specific future date. The security or variable that determines the value of a derivative security is referred to as the **underlying** for the derivative. The value of a derivative at a point in time is derived from the value of the underlying (asset or variable) on which the derivative contract is based.

A relatively simple example of a derivative is a **forward contract** that specifies the price at which one party agrees to buy or sell an underlying security at a specified future date. Consider a forward contract to buy 100 shares of Acme at $30 per share three months from now:

- Acme shares are the **underlying asset** for the forward contract.
- $30 is the **forward price** in the contract.
- The date of the future transaction, when the shares will be exchanged for cash, is referred to as the **settlement date** (maturity date) of the forward contract.
- 100 shares is the **contract size** of the forward contract.
- The forward price is set so that the forward contract has zero value to both parties at contract initiation; neither party pays at the initiation of the contract.

We can examine three outcomes for the price of Acme shares at settlement:

1. The **spot price**, or the market price of the underlying, is $30, equal to the forward price of $30.

   Neither party has profits or losses on the forward contract. Ignoring transactions costs, the party selling Acme shares could buy them back at $30 per share and the party buying the shares could sell them at $30 per share.

2. The spot price of Acme shares is $40, greater than the forward price of $30.

The party buying 100 Acme shares for $3,000 at settlement can sell those shares at the spot price for $4,000, realizing a profit of $1,000 on the forward contract. The party that must deliver the Acme shares delivers shares with a market value of $4,000 and receives $3,000, realizing a $1,000 loss on the forward contract.

3. The spot price of Acme shares is $25 at settlement, less than the forward price of $30.

   The party buying 100 Acme shares for $3,000 at settlement can sell those shares at the market price of $25 to get $2,500 and realize a loss of $500 on the forward contract. The party that must deliver the Acme shares delivers shares with a market value of $2,500 and receives $3,000, realizing a $500 gain on the forward contract.

To summarize, the buyer of the shares in a forward contract will have gains when the market price of the shares at settlement is greater than the forward price, and losses when the market price of the shares at settlement is less than the forward price. The party that must deliver the shares in a forward contract will have gains when the market price of the shares at settlement is less than the forward price, and losses when the market price of the shares at settlement is greater than the forward price. The gains of one party equal the losses of the other party at settlement.

We refer to the party that agrees to buy the underlying asset in a forward contract as the buyer of the forward. The buyer of the forward gains when the price of the underlying increases (and loses when it falls), similarly to a long position in the underlying. In this case we say the forward buyer has *long exposure* to the underlying, while the seller of the underlying has *short exposure* to the underlying, gaining when the price of the underlying decreases and losing when the value of the underlying increases.

In practice, a forward contract may be a **deliverable contract**. In our forward contract example, this means that the payment and the shares must be exchanged at the settlement date. A **cash-settled contract** specifies that only the gains and losses from the forward contract are exchanged at settlement. In our example above, with a share price of $25, cash settlement would require the buyer of Acme shares to pay $500 to the seller of Acme shares at settlement. Ignoring the transaction cost of buying and selling shares in the market, the gains and losses to the parties in our forward contract example are economically equivalent under the two alternative settlement methods.

We can view a derivatives contract as a way to transfer risk from one party to another. Consider a situation where the share seller in the forward contract owns 100 shares of Acme. She has existing risk because the future price of Acme shares is uncertain; the share price three months from now is a random variable. If she enters the forward contract from our example, she will receive $3,000 for her shares at settlement, regardless of their market price. This effectively transfers her existing Acme price risk to the buyer of the shares in the forward contract.

When a party to a derivative contract has an existing risk that is transferred to another party, we say that party has **hedged** (offset, reduced) their existing risk. If the risk of the forward contract exactly matches an existing risk, then the forward contract can be used to fully hedge the existing risk. If a derivative is used to reduce, but not entirely offset, an existing risk, we say the existing risk is **partially hedged**.

If the Acme share buyer in our example has no existing Acme price risk, she clearly increases her risk by entering into the forward contract. In this situation, the Acme share buyer is said to be **speculating** on the future price of Acme shares.

You may have realized our share seller could have achieved her goal of eliminating her Acme price risk by simply selling her shares (a **cash market transaction**). Derivatives have potential advantages over cash market transactions:

- Investors can gain exposure to a risk at low cost, effectively creating a highly leveraged investment in the underlying.
- Transaction costs for a derivatives position may be significantly lower than for the equivalent cash market trade.
- Initiating a derivatives position may have less impact on market prices of the underlying, relative to initiating an equivalent position in the underlying through a cash market transaction.

Underlying Assets and Variables

The underlying for a derivative is most often a stock or bond price, the level of a stock or bond index, or an interest rate. Here, we give examples of different underlying assets and variables for derivative contracts and the nature of the risks they transfer or modify. We present more details about derivatives based on these underlying assets in subsequent readings.

- A bond, for example a forward contract on a 30-year U.S. Treasury bond or other specific bond. The risk involved is the uncertainty about future bond prices.
- An index, for example the S&P 500 Index or the Citi Goldman Sachs Investment Grade Corporate Bond Index. The risk involved is the uncertainty about the future value of the index at a specific date. A portfolio manager can reduce the risk of a portfolio of large U.S. stocks for a period of time by selling a forward on the S&P 500 index. An investor can gain long exposure to a portfolio of high-grade corporate bonds, quickly and at low cost, by buying a forward on the index.
- A currency, for example British pounds (GBP). A U.S. manufacturer that expects a large payment in GBP in six months can offset the uncertainty about the USD value of this payment by selling a forward contract on the expected amount of GBP. A UK manufacturer that must make a large payment in USD in one year can offset the uncertainty about the GBP cost of the payment by buying a forward contract on the USD that is priced in GBP.
- An interest rate, for example the 1-year Treasury bill rate. Similar to derivatives based on bonds, except that a higher interest rate means gains for the buyer of an interest rate forward, whereas higher interest rates mean lower bond prices and losses for the buyer of a bond forward.
- Commodities, which are physical assets including **hard commodities** (typically mined or extracted, such as gold and oil) and **soft commodities** (typically grown, such as cotton, coffee, pork, and cattle). A farmer expecting a cotton crop in four

months can reduce her cotton price risk by selling cotton forward. A utility that will require thousands of gallons of oil over the next year can reduce its oil price risk by buying oil forwards that settle at various times over the coming year.

PROFESSOR'S NOTE

It may help you to remember this common rule for hedging risk with futures, which are similar to forwards: "Do in the futures market what you must do in the future." A baking company that must buy wheat in the future should buy wheat futures (or forwards) to reduce the effects of the uncertainty about future wheat prices on their profits. A farmer who must sell wheat at harvest time should sell wheat futures (or forwards) to reduce price risk.

- Credit derivatives include credit default swaps (CDS), in which one party makes fixed periodic payments to another party, which will make a payment only if the underlying credit instrument (or portfolio of such credit securities) suffers a loss in value due to a default by the issuer (borrower of funds) of the credit instrument.
- Derivative contracts are also created with the weather (for farmers, energy producers, travel and tourism companies), cryptocurrencies, or longevity (for life insurers or annuity providers) as the underlying asset.

Along with forwards and futures, derivatives types that we will cover in the remainder of our derivatives readings are:

- *Options*: Put options give the buyer the right (but not the obligation) to sell the underlying for a specific price in the future. Call options give the buyer the right (but not the obligation) to buy the underlying for a specific price in the future.
- *Swaps*: In a simple interest rate swap, one party agrees to make periodic payments on a given amount at a fixed interest rate, and the other agrees to make periodic interest payments on the same given amount, but at an interest rate based on a future market reference rate (MRR). The resulting cash flows are equivalent to one party (the fixed-rate payer) borrowing at a fixed rate and using the proceeds to buy a floating-rate bond.

LOS 66.b: Describe the basic features of derivative markets, and contrast over-the-counter and exchange-traded derivative markets.

Exchange-Traded Derivatives

Centralized physical exchanges provide markets for futures contracts, some options contracts, and some other derivative contracts. The largest by volume of trades are the National Securities Exchange (India), the B3 market (Brazil), and the CME Group (the United States).

Exchange-traded derivatives are standardized and backed by a central clearinghouse. The exchange specifies the terms of each of the derivative contracts that will be traded and rules for trading on the exchange.

A **central clearinghouse (CCH)** essentially takes the opposite position to each side of a trade (called **novation**), guaranteeing the payments promised under the contract. The CCH requires deposits from both participants when a trade is initiated, and additional deposits for accounts that decline in value, to support its guarantee and minimize counterparty credit risk.

Exchange members (dealers or market makers) buy and sell derivatives at slightly different prices and primarily earn trading profits from the bid/ask spreads between buy and sell prices, rather than from holding (speculating on) specific derivatives positions, although they may hold such positions from time to time to meet customer needs.

The standardization of contracts allows exchange-traded derivatives to be more liquid and more transparent to market participants, compared to customized derivatives. A market participant who has taken a position in exchange-traded derivatives can easily exit that position by entering into a contract with a position opposite to their existing derivatives. Standardization of contracts reduces trading costs compared to customized derivative contracts.

Standardization also facilitates the clearing and settlement of trades. Clearing refers to executing the trade, recording the participants, and handling the exchange of any required payments. Settlement refers to the exchange of underlying assets or payments of the final amounts due at contract settlement (maturity).

Dealer (OTC) Markets for Derivatives

Forwards, most swaps, and some options are custom instruments created and traded by dealers in a market with no central location. Some dealer markets are quite structured (e.g., the Nasdaq market), while others are not. A dealer market with no central location is referred to as an over-the-counter (OTC) market. OTC markets are largely unregulated and less transparent than exchange markets. In OTC markets with no central clearinghouse, each side of a trade faces counterparty credit risk. Dealers (market makers) make derivatives trades with end users of derivatives and may also trade with each other to reduce their exposures to changes in prices of underlying assets.

OTC derivatives contracts can be customized to fit the needs of an end user regarding contract size, definition of the underlying, settlement date, whether the contract is deliverable of cash settled, and other relevant details. Users trying to gain or hedge a specific risk use OTC derivatives when a standardized derivative contract will not meet their needs (including a desire for privacy).

After the financial crisis of 2008, regulators worldwide instituted a **central clearing mandate** requiring that, for many swap trades, **a central counterparty (CCP)** takes on the counterparty credit risk of both sides of a trade, similar to the role of a central clearinghouse. As an example, multiple dealers record their swap trades on a **swap execution facility (SEF)**. When a dealer makes a swap trade, that information is sent to the SEF and the CCP replaces the trade with two trades, with the CCP as the counterparty to both of them, reducing counterparty risk. The downside of this structure is that counterparty risks are concentrated rather than distributed among financial intermediaries.

The following offers a summary of the primary differences between exchange-traded and OTC derivatives.

Exchange-traded derivatives are:

- Traded at a centralized location, an exchange.
- Traded by exchange members (market makers).
- Based on standardized contracts and have lower trading costs.
- Subject to the trading rules of the exchange (i.e., are more regulated).
- Backed by the central clearinghouse to minimize counterparty credit risk. They also require deposits by both parties at initiation, and additional deposits when a position decreases in value.
- More liquid.
- More transparent, as all transactions are known to the exchange and to regulators.

OTC derivatives (not subject to the central clearing mandate) are:

- Custom instruments.
- Less liquid and have higher transaction costs.
- Less transparent.
- Subject to counterparty risk.
- More difficult to clear and settle.
- Subject to higher trading costs.
- Not subject to requirements for the deposit of collateral.

Derivatives in dealer markets that are subject to the central clearing mandate have reduced counterparty risk, are subject to more disclosure of trades, and are easier to clear and settle, but are still customizable and are contracts with dealers or financial intermediaries.

MODULE QUIZ 66.1

1. Which of the following statements *most accurately* describes a derivative security? A derivative:
   A. always increases risk.
   B. has no expiration date.
   C. has a payoff based on an asset value or interest rate.
2. Which of the following statements about exchange-traded derivatives is *least accurate*? Exchange-traded derivatives:
   A. are liquid.
   B. are standardized contracts.
   C. carry significant default risk.

KEY CONCEPTS

LOS 66.a

A derivative is a security that derives its value from value of another security or variable at a specific future date. The security or variable that determines the value of a derivative security is referred to as the underlying.

Basic features of a derivative include the underlying, the price specified in the contract, the contract size, and the settlement date. The price is typically set so the contract has zero value at initiation to both parties. Contracts may be deliverable or cash-settled.

LOS 66.b

Exchange-traded derivatives are standardized and backed by a central clearinghouse that takes the opposite position to each side of a trade, guaranteeing the payments promised under the contract.

Over-the-counter (OTC) derivatives can be customized to fit the needs of the counterparties. OTC markets are largely unregulated and less transparent than exchange markets. Some OTC markets are subject to a central clearing mandate that reduces counterparty credit risk.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 66.1

1. **C** A derivative's value is derived from another asset or an interest rate. (LOS 66.a)

2. **C** Exchange-traded derivatives have relatively low default risk (counterparty credit risk) because the clearinghouse stands between the counterparties involved, in most contracts. (LOS 66.b)

READING 67

FORWARD COMMITMENT AND CONTINGENT CLAIM FEATURES AND INSTRUMENTS

MODULE 67.1: FORWARDS AND FUTURES

Video covering this content is available online.

LOS 67.a: Define forward contracts, futures contracts, swaps, options (calls and puts), and credit derivatives and compare their basic characteristics.

Forward Contracts

In a **forward contract** between two parties, one party (the buyer) commits to buy and the other party (the seller) commits to sell a physical or financial asset at a specific price on a specific date (the settlement date) in the future.

The buyer has long exposure to the underlying asset in that he will make a profit on the forward if the price of the underlying at the settlement date exceeds the forward price, and have a loss if the price of the underlying at the settlement date is less than the forward price. The results are opposite for the seller of the forward, who has short exposure to the underlying asset.

Futures Contracts

A **futures contract** is quite similar to a forward contract but is standardized and exchange-traded. The primary ways in which forwards and futures differ are that futures trade in a liquid secondary market, are subject to greater regulation, and trade in markets with more disclosure (transparency). Futures are backed by a central clearinghouse and require daily cash settlement of gains and losses, so that counterparty credit risk is minimized.

On a futures exchange, **margin** is cash or other acceptable collaterals that both the buyer and seller must deposit. Unlike margin in bond or stock accounts, there is no loan involved and, consequently, there are no interest charges. This collateral provides protection for the clearinghouse. At the end of each trading day, the margin balance in a futures account is adjusted for any gains and losses in the value of the futures position based on the new settlement price, a process called the **mark-to-market** or marking-to-market. The settlement price is calculated as the average price of trades over a period at the end of the trading session.

Initial margin is the amount of cash or collateral that must be deposited in a futures account before a trade may be made. Initial margin per contract is relatively low and is approximately one day's maximum expected price fluctuation on the total value of the assets covered by the contract.

Maintenance margin is the minimum amount of margin that must be maintained in a futures account. If the margin balance in the account falls below the maintenance margin through daily mark to market from changes in the futures price, the account holder must deposit additional funds to bring the margin balance back up to the *initial* margin amount, or the exchange will close out the futures position. This is different from a margin call in an equity account, which requires investors only to bring the margin back up to the maintenance margin amount. Futures margin requirements are set by the exchange.

To illustrate the daily mark-to-market for futures, consider a contract for 100 ounces of gold that settles on May 15. The initial margin amount is $5,000 and the maintenance margin is $4,700.

On Day 0

- A buyer and seller make a trade at the end of the day at a price of $1,950 per ounce and both parties deposit the initial margin of $5,000 into their accounts.

On Day 1, the settlement price falls to $1,947.50. The seller has gains and the buyer has losses.

- The exchange will credit the seller's account for (1,950 – 1,947.50) × 100 = $250, increasing the margin balance to $5,250.
- The exchange will deduct (1,950 – 1,947.50) × 100 = $250 from the buyer's account, decreasing the margin balance to $4,750. Because $4,750 is more than the maintenance (minimum) margin amount of $4,700, no additional deposit is required.

On Day 2, the settlement price falls to $1,945. Again, the seller has gains and the buyer has losses.

- The exchange will credit the seller's account for (1,947.50 – 1,945) × 100 = $250, increasing their margin balance to $5,500.
- The exchange will deduct (1,947.50 – 1,945) × 100 = $250 from the buyer's account, decreasing the margin balance to $4,500. Because $4,500 is less than the maintenance (minimum) margin amount of $4,700, the buyer must deposit 5,000 – 4,500 = $500 into their margin account to return it to the initial margin amount of $5,000.
- At the end of Day 2, both parties have futures positions at the new settlement price of $1,945 per ounce.

Many futures contracts have **price limits**, which are exchange-imposed limits on how much each day's settlement price can change from the previous day's settlement price. Exchange members are prohibited from executing trades at prices outside these limits. If the equilibrium price at which traders would willingly trade is above the upper limit or below the lower limit, trades cannot take place. Some exchanges have **circuit breakers**; in this case, when a futures price reaches a limit price, trading is suspended for a short period.

MODULE QUIZ 67.1

1. Which type of contract always requires daily marking to market of gains and losses?
   A. Futures contracts only.
   B. Forward contracts only.
   C. Both futures and forward contracts.
2. Compared to a futures contract, an otherwise identical forward contract *most likely* has greater:
   A. liquidity.
   B. transparency.
   C. counterparty risk.

MODULE 67.2: SWAPS AND OPTIONS

Video covering this content is available online.

Swaps

Swaps are agreements to exchange a series of payments on multiple settlement dates over a specified time period (e.g., quarterly payments for two years). At each settlement date, the two payments are netted so that only one net payment is made. The party with the greater liability at each settlement date pays the net difference to the other party.

Swaps trade in a dealer market and the parties are exposed to counterparty credit risk, unless the market has a central counterparty structure to reduce counterparty risk. In this case, margin deposits and mark-to-market payments may also be required to further reduce counterparty risk.

We can illustrate the basics of a swap with a simple fixed-for-floating interest rate swap for two years with quarterly interest payments based on a **notional principal** amount of $10 million. In such a swap, one party makes quarterly payments at a fixed rate of interest (the **swap rate**) and the other makes quarterly payments based on a floating **market reference rate**.

The swap rate is set so that the swap has zero value to each party at its inception. As expectations of future values of the market reference rate change over time, the value of the swap can become positive for one party and negative for the other party.

Consider an interest rate swap with a notional principal amount of $10 million, a fixed rate of 2%, and a floating rate of the 90-day secured overnight financing rate (SOFR). At each settlement date, the fixed-rate payment will be $10 million × 0.02/4 = $50,000. The floating-rate payment at the end of the first quarter will be based on 90-day SOFR at the initiation of the swap, so that both payments are known at the inception of the swap.

If, at the end of the first quarter, 90-day SOFR is 1.6%, the floating-rate payment at the second quarterly settlement date will be $10 million × 0.016 / 4 = $40,000. The fixed-rate payment is again $50,000, so at the end of the second quarter the fixed-rate payer will pay the net amount of $10,000 to the other party.

A company with 2-year floating-rate quarterly-pay note outstanding could enter such a swap as the fixed-rate payer, converting its floating-rate liability into a fixed-rate liability. It now makes fixed interest rate payments and can use the floating-rate payments from the counterparty to make the payments on its floating-rate debt. By entering into the swap, the company can hedge the interest rate risk (uncertainty about future quarterly rates) of their existing floating-rate liability.

As we will see in our reading on swap valuation, a swap can be constructed from a series of forward contracts in which the underlying is a floating rate and the forward price is a fixed rate. Each forward settles on one of the settlement dates of the swap. At each settlement date, the difference between the fixed and the floating rates would result in a net payment, just as with a swap. Often, interest rate forwards settle at the beginning of the quarter rather than the end; the cash flows are the present value equivalents of the end-of-quarter swap payments.

Credit Swaps

One type of swap that is structured a bit differently is a **credit default swap (CDS)**. With a CDS, the protection buyer makes fixed payments on the settlement dates and the protection seller pays only if the underlying (a reference security) has a **credit event**. This could be a bond default, a corporate bankruptcy, or an involuntary restructuring.

When a credit event occurs, the protection seller must pay an amount that offsets the loss in value of the reference security. The fixed payments represent the yield premium on the reference bonds that compensates bondholders for the expected loss from default, the probability of default times the expected loss in the event of default (or other credit event). The protection buyer is essentially paying the yield premium on the reference security for insurance against default.

The holder of a risky bond can hedge its default risk by entering a CDS as the protection buyer. The protection seller receives the default risk premium (credit spread) and takes on the risk of default, resulting in risk exposure similar to that of holding the reference bond.

Options

The two types of options of interest to us here are **put options** and **call options** on an underlying asset. We introduce them using option contracts for 100 shares of a stock as the underlying asset.

A put option gives the buyer the right (but not the obligation) to sell 100 shares at a specified price (the **exercise price**, also referred to as the **strike price**) for specified period of time, the **time to expiration**. The put seller (also called the *writer* of the option) takes on the obligation to purchase the 100 shares at the price specified in the option, if the put buyer exercises the option.

Note the “one-way” nature of options. If the exercise price of the puts is $25 at the expiration of the option, and the shares are trading at or above $25, the put holder will not exercise the option. There is no reason to exercise the put and sell shares at $25 when they can be sold for more than $25 in the market. This is the outcome for any stock price greater than or equal to $25. Regardless of whether the stock price at option expiration is $25 or $1,000, the put buyer lets the option expire, and the put seller keeps the proceeds from the sale.

If the stock price is below $25, the put buyer will exercise the option and the put seller must purchase 100 shares for $25 from the put buyer. On net, the put buyer essentially receives the difference between the stock price at expiration and $25 (times 100 shares).

A call option gives the buyer the right (but not the obligation) to buy 100 shares at a specified price (the exercise price) for a specified period of time. The call seller (writer) takes on the obligation to sell the 100 shares at the exercise price, if the call buyer exercises the option.

LOS 67.b: Determine the value at expiration and profit from a long or a short position in a call or put option.

Unlike forwards, futures, and swaps, options are sold at a price (they do not have zero value at initiation). The price of an option is also referred to as the **option premium**.

At expiration the payoff (value) of a call option to the owner is Max (0, S – X), where *S* is the price of the underlying at expiration and *X* is the exercise price of the call option. The Max ( ) function tells us that if S < X at expiration, the option value is zero, that is, it expires worthless and will not be exercised.

At expiration the payoff (value) of a put option to the owner is Max (0, X – S), where *S* is the price of the underlying at expiration and *X* is the exercise price of the put option. A put has a zero value at expiration unless X – S is positive.

For the buyer of a put or call option, the profit at expiration is simply the difference between the value (payoff) of the option at expiration and the premium the investor paid for the option.

Because the seller (writer) of an option receives the option premium, the profit to the option seller at expiration is the amount of the premium received minus the option payoff at expiration. The writer loses the payoff at expiration and will have a loss on the option if the payoff is greater than the premium received.

Note the risk exposures of call and put buyers and writers. The buyer of a put or call has no further obligation, so the maximum loss to the buyer is simply the amount they paid for the option. The writer of a call option has exposure to an unlimited loss because the maximum price of the underlying, *S*, is (theoretically) unlimited, so that the payoff S – X is unlimited. The payoff on a put option is X – S, so if the lower limit on *S* is zero, the maximum payoff on a put option is the exercise price, *X*.

Call Option Profits and Losses

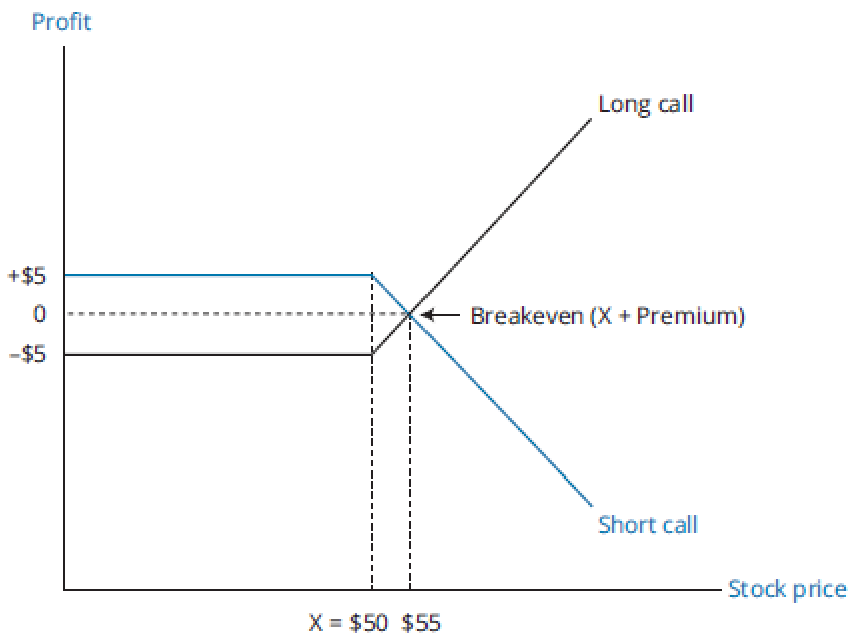
Consider a call option with a premium of $5 and an exercise price of $50. This means the buyer pays $5 to the writer. At expiration, if the price of the stock is less than or equal to the $50 exercise price, the option has zero value, the buyer of the option is out

$5, and the writer of the option is ahead $5. When the stock's price exceeds $50, the option starts to gain (breakeven will come at $55, when the value of the stock equals the exercise price plus the option premium. Conversely, as the price of the stock moves upward, the seller of the option starts to lose (negative figures will start at $55, when the value of the stock equals the exercise price plus the option premium).

An illustration of the profit or loss at expiration for the buyer (long) and writer (short) of this call option, as a function of the stock price, is presented in Figure 67.1. This profit/loss diagram indicates the following:

- The maximum loss for the buyer of a call is the $5 premium (at any S ≤ $50).
- The breakeven point for the buyer and seller is the exercise price plus the premium (at S = $55).
- The profit potential to the buyer of the option is unlimited, and, conversely, the potential loss to the writer of the call option is unlimited.
- The call holder will exercise the option whenever the stock's price exceeds the exercise price at the expiration date.
- The greatest profit the writer can make is the $5 premium (at any S ≤ $50).
- The sum of the profits between the buyer and seller of the call option is always zero; thus, trading options is a *zero-sum game*. One party's profits equal the other party's losses.

Figure 67.1: Profit/Loss Diagram for a Call Option



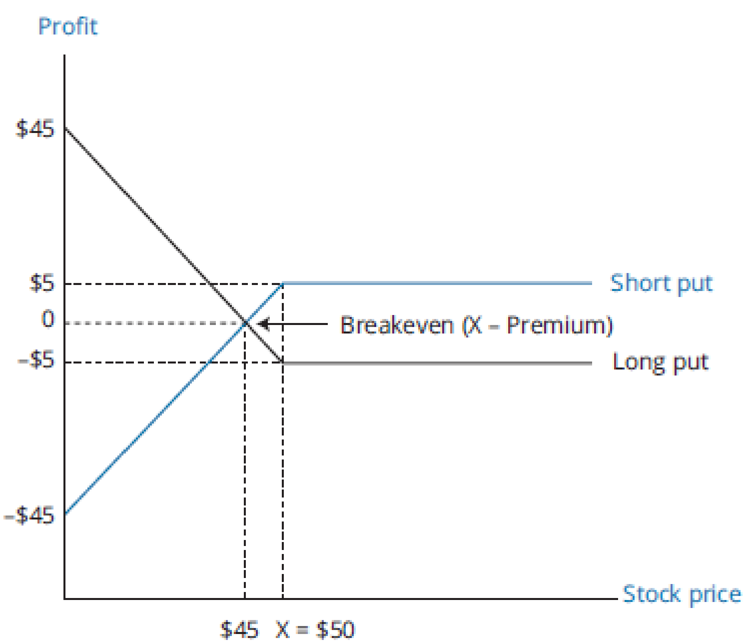
Put Option Profits and Losses

To examine the profits and losses associated with trading put options, consider a put option with a $5 premium and a $50 exercise price. The buyer pays $5 to the writer. When the price of the stock at expiration is greater than or equal to the $50 exercise price, the put has zero value. The buyer of the option has a loss of $5 and the writer of the option has a gain of $5. When the stock price is less than $50, the put option has a positive payoff. Breakeven will come at $45, when the value of the stock equals the exercise price less the option premium. At a stock price below $45, the put seller will have a loss.

Figure 67.2 shows the profit/loss diagram for the buyer (long) and seller (short) of the put option that we have been discussing. This profit/loss diagram illustrates that:

- The maximum loss for the buyer of the put is the $5 premium (at any S ≥ $50).
- The maximum gain to the buyer of the put is limited to the exercise price less the premium ($50 – $5 = $45). The potential loss to the writer of the put is the same amount.
- The breakeven price for the put buyer (seller) is the exercise price minus the option premium ($50 – $5 = $45).
- The maximum profit for the writer is the $5 premium (S ≥ $50).
- The profit (loss) of the put buyer will always equal the loss (profit) of the put writer.

Figure 67.2: Profit/Loss Diagram for a Put Option



EXAMPLE: Option profit calculations

Suppose that both a call option and a put option have been written on a stock with an exercise price of $40. The current stock price is $42, and the call and put premiums are $3 and $0.75, respectively.

Calculate the profit to the long and short positions for both the put and the call with an expiration day stock price of $35 and with a price at expiration of $43.

Answer:

Profit will be computed as ending option value – initial option cost.

Stock at $35:

- Long call: $0 – $3 = –$3. The option has no value, so the buyer loses the premium paid.
- Short call: $3 – $0 = $3. Because the option has no value, the call writer's gain equals the premium received.
- Long put: $5 – $0.75 = $4.25. The buyer paid $0.75 for an option that is now worth $5.
- Short put: $0.75 – $5 = –$4.25. The seller received $0.75 for writing the option, but the option will be exercised so the seller will lose $5 at expiration.

Stock at $43:

- Long call: –$3 + $3 = $0. The buyer paid $3 for the option, and it is now in the money by $3. Hence, the net profit is zero.
- Short call: $3 – $3 = $0. The seller received $3 for writing the option and now faces a –$3 valuation because the buyer will exercise the option, for a net profit of zero.
- Long put: –$0.75 – $0 = –$0.75. The buyer paid $0.75 for the put option and the option now has no value.
- Short put: $0.75 – $0 = $0.75. The seller received $0.75 for writing the option and it has zero value at expiration.

A buyer of puts or a seller of calls has short exposure to the underlying (will profit when the price of the underlying asset decreases). A buyer of calls or a seller of puts has long exposure to the underlying (will profit when the price of the underlying asset increases).

LOS 67.c: Contrast forward commitments with contingent claims.

A **forward commitment** is a legally binding promise to perform some action in the future. Forward commitments include forward contracts, futures contracts, and most swaps.

A **contingent claim** is a claim (to a payoff) that depends on a particular event. Options are contingent claims; the event is the price of the underlying being above or below the exercise price. Credit default swaps are also considered contingent claims because the payment by the protection seller depends on a credit event occurring.

MODULE QUIZ 67.2

1. Interest rate swaps are:
   A. highly regulated.
   B. equivalent to a series of forward contracts.
   C. contracts to exchange one asset for another.
2. A call option is:
   A. the right to sell at a specific price.
   B. the right to buy at a specific price.

C. an obligation to buy at a certain price.

3. At expiration, the exercise value of a put option is:
   A. positive if the underlying asset price is less than the exercise price.
   B. zero only if the underlying asset price is equal to the exercise price.
   C. negative if the underlying asset price is greater than the exercise price.
4. At expiration, the exercise value of a call option is the:
   A. underlying asset price minus the exercise price.
   B. greater of zero or the exercise price minus the underlying asset price.
   C. greater of zero or the underlying asset price minus the exercise price.
5. An investor writes a put option with an exercise price of $40 when the stock price is $42. The option premium is $1. At expiration the stock price is $37. The investor will realize a:
   A. loss of $2.
   B. loss of $3.
   C. profit of $1.
6. Which of the following derivatives is a forward commitment?
   A. Stock option.
   B. Interest rate swap.
   C. Credit default swap.

KEY CONCEPTS

LOS 67.a

Forward contracts obligate one party to buy, and another to sell, a specific asset at a specific price at a specific time in the future.

Futures contracts are much like forward contracts, but are exchange-traded, liquid, and require daily settlement of any gains or losses.

A call option gives the holder the right, but not the obligation, to buy an asset at a specific price at some time in the future.

A put option gives the holder the right, but not the obligation, to sell an asset at a specific price at some time in the future.

In an interest rate swap, one party pays a fixed rate and the other party pays a floating rate, on a given amount of notional principal. Swaps are equivalent to a series of forward contracts based on a floating rate of interest.

A credit default swap is a contract in which the protection seller provides a payment if a specified credit event occurs.

LOS 67.b

Call option value at expiration is Max(0, underlying price minus exercise price) and profit or loss is Max(0, underlying price minus exercise price) minus the option cost (premium paid).

Put value at expiration is Max(0, exercise price minus underlying price) and profit or loss is Max(0, exercise price minus underlying price) minus the option cost.

A call buyer (call seller) benefits from an increase (decrease) in the value of the underlying asset.

A put buyer (put seller) benefits from a decrease (increase) in the value of the underlying asset.

LOS 67.c

A forward commitment is an obligation to buy or sell an asset or make a payment in the future. Forward contracts, futures contracts, and most swaps are forward commitments.

A contingent claim is a derivative that has a future payoff only if some future event takes place (e.g., asset price is greater than a specified price). Options and credit derivatives are contingent claims.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 67.1

1. **A** Futures contracts are marked to market daily. Forward contracts typically are not, but could be if there is central clearing party. (LOS 67.a)
2. **C** Forward contracts involve counterparty risk; futures contracts trade through a clearinghouse. Because futures contracts trade on organized exchanges, they have greater liquidity and transparency than forward contracts. (LOS 67.a)

Module Quiz 67.2

1. **B** A swap is an agreement to buy or sell an underlying asset periodically over the life of the swap contract. It is equivalent to a series of forward contracts. (LOS 67.a)
2. **B** A call gives the owner the right to call an asset away (buy it) from the seller. (LOS 67.a)
3. **A** The exercise value of a put option is positive at expiration if the underlying asset price is less than the exercise price. Its exercise value is zero if the underlying asset price is greater than or equal to the exercise price. The exercise value of an option cannot be negative because the holder can allow it to expire unexercised. (LOS 67.b)
4. **C** If the underlying asset price is greater than the exercise price of a call option, the value of the option is equal to the difference. If the underlying asset price is less than the exercise price, a call option expires with a value of zero. (LOS 67.b)
5. **A** Because the stock price at expiration is less than the exercise price, the buyer of the put option will exercise it against the writer. The writer will have to pay $40 for the stock and can only sell it for $37 in the market. However, the put writer collected the $1 premium for writing the option, which reduces the net loss to $2. (LOS 67.b)

6. **B** This type of custom contract is a forward commitment. (LOS 67.c)

READING 68

DERIVATIVE BENEFITS, RISKS, AND ISSUER AND INVESTOR USES

MODULE 68.1: USES, BENEFITS, AND RISKS OF DERIVATIVES

Video covering this content is available online.

LOS 68.a: Describe benefits and risks of derivative instruments.

Advantages of Derivatives

Derivative instruments offer several potential advantages over cash market transactions, including the following:

Ability to Change Risk Allocation, Transfer Risk, and Manage Risk

We have discussed these benefits in our introduction to derivative contracts. Some examples of ways that risk exposures can be altered using derivatives, without any cash market securities transactions, are:

- A portfolio manager can increase or decrease exposure to the risk and return of a market index.
- A manufacturer can hedge the exchange rate risk of anticipated receipts or payments.
- The issuer of a floating-rate note can change that exposure to a fixed-rate obligation.

Derivative instruments can be used to create risk exposures that are not available in cash markets. Consider the following examples of changing an existing risk profile:

- The owner of common stock can buy puts that act as a floor on the sale price of their shares, reducing the downside risk of the stock by paying the cost of the puts.
- An investor can acquire the upside potential of an asset without taking on its downside risk by buying call options.

Information Discovery

Derivatives prices and trading provide information that cash market transactions do not.

- Options prices depend on many things we can observe (interest rates, price of the underlying, time to expiration, and exercise price) and one we cannot, the expected future price volatility of the underlying. We can use values of the observable variables, together with current market prices of derivatives, to estimate the future price volatility of the underlying that market participants expect.

- Futures and forwards can be used to estimate expected prices of their underlying assets.
- Interest rate futures across maturities can be used to infer expected future interest rates and even the number of central bank interest rate changes over a future period.

Operational Advantages

Compared to cash markets, derivatives markets have several operational advantages. Operational advantages of derivatives include greater ease of short selling, lower transaction costs, greater potential leverage, and greater liquidity.

- *Ease of short sales*. Taking a short position in an asset by selling a forward or a futures contract may be easy to do. Difficulty in borrowing an asset and restrictions on short sales may make short positions in underlying assets problematic or more expensive.
- *Lower transaction costs.* Transaction costs can be significantly lower with commodities derivatives, where transportation, storage, and insurance add costs to transactions in physical commodities. Entering a fixed-for-floating swap to change a floating-rate exposure to fixed rate is clearly less costly than retiring a floating-rate note and issuing a fixed-rate note.
- *Greater leverage*. The cash required to take a position in derivatives is typically much less than for an equivalent exposure in the cash markets.
- *Greater liquidity.* The low cash requirement for derivatives transactions makes very large transactions easier to handle.

Improved Market Efficiency

Low transaction costs, greater liquidity and leverage, and ease of short sales all make it less costly to exploit securities mispricing through derivatives transactions and improve the efficiency of market prices.

Risks of Derivatives

Implicit Leverage

The implicit leverage in derivatives contracts gives them much more risk than their cash market equivalents. Just as we have shown regarding the leverage of an equity investment on margin, a lower cash requirement to enter a trade increases leverage. Futures margins, according to the CME Group, are typically in the 3% to 12% range, indicating leverage of 8:1 to 33:1. With required cash margin of 4%, a 1% decrease in the futures price decreases the cash margin by 25%.

A lack of transparency in derivatives contracts and securities that combine derivative and cash market exposures (structured securities) may lead to situations in which the purchasers do not well understand the risks of derivatives or securities with embedded derivatives.

Basis Risk

Basis risk arises when the underlying of a derivative differs from a position being hedged with the derivative. For a manager with a portfolio of 50 large-cap U.S. stocks, selling a forward with the S&P 500 Index as the underlying (in an amount equal to the portfolio value) would hedge portfolio risk, but would not eliminate it because of the possibility that returns on the portfolio and returns on the index may differ over the life of the forward. Basis risk also arises in a situation where an investor's horizon and the settlement date of the hedging derivative differ, such as hedging the value of a corn harvest that will occur on September 15 by selling corn futures that settle on October 1. Again the hedge may be effective but will not be perfect, and the corn producer is said to have basis risk.

Liquidity Risk

Derivative instruments have a special type of liquidity risk when the cash flows from a derivatives hedge do not match the cash flows of the investor positions. As an example, consider a farmer who sells wheat futures to hedge the value of her wheat harvest. If the future price of wheat increases, losses on the short position essentially offset the extra income from the higher price that will come at harvest (as intended with a hedge), but these losses may also cause the farmer to get margin calls during the life of the contract. If the farmer does not have the cash (liquidity) to meet the margin calls, the position will be closed out and the value of the hedge will be lost.

Counterparty Credit Risk

We have discussed counterparty credit risk previously. Here we note additionally that different derivatives and positions have important differences in the existence or amount of counterparty risk. The seller of an option faces no counterparty credit risk; once the seller receives the option premium there is no circumstance in which the seller will be owed more at settlement. On the other hand, the buyer of an option will be owed money at settlement if the option is in the money; thus, the buyer faces counterparty credit risk. In contrast, both the buyer and seller of a forward on an underlying asset may face counterparty credit risk.

In futures markets the deposit of initial margin, the daily mark-to-market, and the guarantee of the central clearinghouse all reduce counterparty risk. With forwards there may be no guarantees, or the terms of the forward contract may specify margin deposits, a periodic mark-to-market, and a central clearing party to mitigate credit risk.

Systemic Risk

Widespread impact on financial markets and institutions may arise from excessive speculation using derivative instruments. Market regulators attempt to reduce systemic risk though regulation, for example the central clearing requirement for swap markets to reduce counterparty credit risk.

LOS 68.b: Compare the use of derivatives among issuers and investors.

Derivatives Use by Issuers

Corporate users of derivative instruments are considered issuers of derivatives. A non-financial corporation may have risks associated with changes in asset and liability values as well as earnings volatility from changes in various underlying securities or interest rates. Some examples are:

- A corporation may have income in a foreign currency and hedge the exchange rate risk with forwards to smooth earnings reported in their domestic currency.
- A corporation may use fair value reporting for its fixed-rate debt, and that value changes as interest rates change. By entering an interest rate swap as the floating-rate payer, the corporation has essentially converted the fixed-rate liability to a floating-rate liability that has much lower duration so that its balance sheet value is less sensitive to changes in interest rates.
- A corporation with a commodity-like product may carry its inventory at fair market value, leading to fluctuations in the value reported on the balance sheet over time as the market price of their product changes. By selling forward contracts on an underlying that matches well with their product, the firm will have gains or losses on the forwards that offset decreases or increases in reported inventory value. With the market value of the forward position also reported on the balance sheet, total assets will have less variation from changes in the market price of their product.

Accounting rules may permit **hedge accounting**. Hedge accounting allows firms to recognize the gains and losses of qualifying derivative hedges at the same time they recognize the corresponding changes in the values of assets or liabilities being hedged. Issuer hedges against the effects of a changing price or value of a derivative's underlying are classified by their purpose.

- A hedge of the domestic currency value of future receipts in a foreign currency using forwards is termed a **cash flow hedge**. A swap that converts a floating-rate liability to a fixed-rate liability is also considered a cash flow hedge (cash flows for interest payments are more certain).
- A **fair value hedge** is one that reduces (offsets) changes in the values of the firm's assets or liabilities. Our examples of a firm that uses derivatives to hedge against changes in the balance sheet value of its inventory, and a firm that uses an interest rate swap to decrease the volatility of debt values on its balance sheet, are considered fair value hedges.
- A **net investment hedge** is one that reduces the volatility of the value of the equity of a company's foreign subsidiary reported on its balance sheet. Foreign currency forwards or futures can be used to hedge changes in the reported value of the subsidiary's equity due to changes in exchange rates.

Derivatives Use by Investors

As we have seen, investors can hedge, modify, or increase their exposure to the risk of an underlying asset or interest rate with derivatives positions, either forward commitments or contingent claims. Some examples are:

- An investor can buy silver forwards to gain exposure to the price of silver, with no or low funds initially required.
- An investor can increase the duration of their bond portfolio by entering an interest rate swap as the floating-rate payer/fixed-rate receiver, which is similar to issuing floating-rate debt and buying a fixed-rate bond with the proceeds.
- An equity portfolio manager can modify their market risk exposure temporarily at low cost, increasing it by buying equity index futures or decreasing it by selling equity index futures. Alternatively, the portfolio manager could decrease downside risk and preserve upside potential by buying puts on an equity index.

MODULE QUIZ 68.1

1. Which of the following *most accurately* describes a risk of derivative instruments?
   A. Derivatives make it easier for market participants to take short positions.
   B. The underlying of a derivative might not fully match a position being hedged.
   C. Volatility in underlying asset prices is implied by the prices of options on those assets.
2. Uses of derivatives by investors *most likely* include:
   A. hedging against price risk for inventory held.
   B. modifying the risk exposure of a securities portfolio.
   C. stabilizing the balance sheet value of a foreign subsidiary.

KEY CONCEPTS

LOS 68.a

Advantages of derivatives include the ability to change or transfer risk; information discovery about the expected prices or volatility of underlying assets or interest rates; operational advantages such as ease of short sales, low transaction costs, and greater leverage and liquidity; and improved market efficiency.

Risks of derivatives include implicit leverage, basis risk from inexact hedges, liquidity risk from required cash flows, counterparty credit risk, and systemic risk for financial markets.

LOS 68.b

Derivatives uses by issuers include managing risks associated with changes in asset and liability values as well as earnings volatility from changes in various underlying securities or interest rates.

Derivatives uses by investors include hedging, modifying, or increasing their exposure to the risk of an underlying asset or interest rate.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 68.1

1. **B** Basis risk arises when the underlying of a derivative differs from a position being hedged. Ease of taking short positions with derivatives compared to their underlying assets, and the information about implied volatility that is revealed by option prices, are two of the advantages of derivative instruments. (LOS 68.a)

2. **B** Modifying the risk exposure of a securities portfolio is an example of derivatives use by investors. Hedging against price risk for inventory and stabilizing the balance sheet value of a foreign subsidiary are examples of derivatives use by issuers. (LOS 68.b)

READING 69

ARBITRAGE, REPLICATION, AND THE COST OF CARRY IN PRICING DERIVATIVES

MODULE 69.1: ARBITRAGE, REPLICATION, AND CARRYING COSTS

Video covering this content is available online.

LOS 69.a: Explain how the concepts of arbitrage and replication are used in pricing derivatives.

In contrast to valuing risky assets as the (risk-adjusted) present value of expected future cash flows, the valuation of derivative securities is based on a **no-arbitrage condition**. *Arbitrage* refers to a transaction in which an investor purchases one asset or portfolio of assets at one price and simultaneously sells an asset or portfolio of assets that has the same future payoffs, regardless of future events, at a higher price, realizing a risk-free gain on the transaction.

While arbitrage opportunities may be rare, the reasoning is that when they do exist, they will be exploited rapidly. Therefore, we can use a no-arbitrage condition to determine the current value of a derivative, based on the known value of a portfolio of assets that has the same future payoffs as the derivative, regardless of future events. Because there are transaction costs of exploiting an arbitrage opportunity, small differences in price may persist when the arbitrage gain is less than the transaction costs of exploiting it.

We can illustrate no-arbitrage pricing with a 1-year forward contract, with a forward price of $F_0(1)$, on an Acme share that pays no dividends and is trading at a current price, S_0, of \$30.

Consider two strategies to own an Acme share at t =1:

- *Portfolio 1*: Buy a pure discount bond with a yield of 5% that pays $F_0(1)$ at t = 1. The current cost of the bond is $F_0(1)/1.05$. Additionally, enter a forward contract on one Acme share at $F_0(1)$ as the buyer. The forward has a zero cost, so the cost of Portfolio 1 is $F_0(1)/1.05$.

At $t = 1$ the bond pays $F_0(1)$, which will buy an Acme share at the forward price, so that the payoff on Portfolio 1 is the value of one share at $t = 1$, S_1.

- *Portfolio 2:* Buy a share of Acme at $S_0 = 30$ and hold it for one year. Cost at $t = 0$ is $30.

  At $t = 1$ the value of the Acme share is S_1, and this is the payoff for Portfolio 2.

The no-arbitrage condition (law of one price) requires that two portfolios with the same payoff in the future for any future value of Acme have the same cost today. Because our two portfolios have a payoff of S_1, they must have the same cost at $t = 0$ to prevent arbitrage. That is, $F_0(1)/1.05 = \$30$, so we can solve for the no-arbitrage forward price as $F_0(1) = 30(1.05) = 31.50$.

To better understand the no-arbitrage condition, we will consider two situations in which the forward price is not at its no-arbitrage value: $F_0(1) > 31.50$ and $F_0(1) < 31.50$.

- If the forward contract price is 32 ($F_0(1) > 31.50$), the profitable arbitrage is to sell the forward (because the forward price is "too high") and buy a share of stock. At t = 1, deliver the share under the forward contract and receive 32, for a return of 32/30 – 1 = 6.67%, which is higher than the risk-free rate.

  We can also view this transaction as borrowing 30 at the risk-free rate (5%) to buy the Acme share at $t = 0$, and at $t = 1$ paying 31.50 to settle the loan. The share delivered under the forward has a contract price of 32, so the arbitrageur has an arbitrage profit of 32 – 31.50 = 0.50 with no risk and no initial cost.
- If the forward contract price is 31 ($F_0(1) < 31.50$), the profitable arbitrage is to buy the forward and sell short an Acme share at $t = 0$. The proceeds of the short sale, 30, can be invested at the risk-free rate to produce 30(1.05) = 31.50 at $t = 1$. The forward contract requires the purchase of a share of Acme for 31, which the investor can return to close out the short position. The profit to an arbitrageur is 31.50 – 31 = 0.50. With no cash investment at $t = 0$, the investor receives an arbitrage profit of 0.50 at t = 1.

When the forward price is "too high," the arbitrage is to sell the forward and buy the underlying asset. When the forward price is "too low," the arbitrage is to buy the forward and sell (short) the underlying asset. In either case, the actions of arbitrageurs will move the forward price toward its no-arbitrage level until arbitrage profits are no longer possible.

Replication refers to creating a portfolio with cash market transactions that has the same payoffs as a derivative for all possible future values of the underlying.

Our arbitrage example for Acme forwards will serve to illustrate replication.

A long forward on an Acme share can be replicated by borrowing 30 at 5% to purchase an Acme share, and repaying the loan on the settlement date of the forward. At settlement ($t = 1$), the payoff on the replication is $S_1 - 30(1.05) = S_1 - 31.50$ (value of one share minus the repayment of the loan), the same as the payoff on a long forward at 31.50, for any value of Acme shares at settlement.

A short forward on an Acme share can be replicated by shorting an Acme share and investing the proceeds of 30 at 5%. At settlement the investor receives 31.50 from the investment of short sale proceeds, and must buy a share of Acme for S_1. The payoff on the replicating portfolio is 31.50 – S_1, the same as the payoff on a short forward at 31.50, for any value of Acme shares at settlement.

These replications allow us to calculate the no-arbitrage forward price of an asset, just as we did in our example using Acme shares. Because our replicating portfolio for a long forward has the same payoff as a long forward at time = T, the payoff at settlement on a portfolio that is long the replicating portfolio and short the forward must be zero to prevent arbitrage. For this strategy, when the forward is priced at its no-arbitrage value the payoff at time = T is:

$$S_T - S_0(1 + Rf)^T - [S_T - F_0(T)] = 0$$

$$\text{so that } F_0(T) - S_0(1 + Rf)^T = 0 \text{ and } F_0(T) = S_0(1 + Rf)^T.$$

For a portfolio that is short the replicating portfolio and long the forward, the payoff at time *T* is:

$$S_0(1 + Rf)^T - S_T + [S_T - F_0(T)] = 0$$

$$\text{so that } S_0(1 + Rf)^T - F_0(T) = 0 \text{ and } F_0(T) = S_0(1 + Rf)^T.$$

The forward price that will prevent arbitrage is $S_0(1 + Rf)^T$, just as we found in our example of a forward contract on an Acme share.

LOS 69.b: Explain the difference between the spot and expected future price of an underlying and the cost of carry associated with holding the underlying asset.

When we derived the no-arbitrage forward price for an asset as $F_0(T) = S_0(1 + Rf)^T$, we assumed there were no benefits of holding the asset and no costs of holding the asset, other than the opportunity cost of the funds to purchase the asset (the risk-free rate of interest).

Any additional costs or benefits of holding the underlying asset must be accounted for in calculating the no-arbitrage forward price. There may be additional costs of owning an asset, especially with commodities, such as storage and insurance costs. For financial assets, these costs are very low and not significant.

There may also be monetary benefits to holding an asset, such as dividend payments for equities and interest payments for debt instruments. Holding commodities may have non-monetary benefits, referred to as **convenience yield**. If an asset is difficult to sell short in the market, owning it may convey benefits in circumstances where selling the asset is advantageous. For example, a shortage of the asset may drive prices up temporarily, making sale of the asset in the short term profitable.

We denote the present value of any costs of holding the asset from time 0 to settlement at time *T* (e.g., storage, insurance, spoilage) as PV_0(cost), and the present value of any cash flows from the asset or convenience yield over the holding period as PV_0(benefit).

Consider first a case where there are storage costs of holding the asset, but no benefits. For an asset with no costs or benefits of holding the asset, we established the no-arbitrage forward price as $S_0(1 + Rf)^T$, the cost of buying and holding the underlying asset until time *T*. When there are storage costs to hold the asset until time *T*, an arbitrageur must both buy the asset and pay the present value of storage costs at *t* = 0. This increases the no-arbitrage price of a 1-year forward to $[S_0 + PV_0(\text{cost})](1 + Rf)^T$. Here we see that *costs of holding an asset increase its no-arbitrage forward price*.

Next consider a case where holding the asset has benefits, but no costs. Returning to our example of a 1-year forward on a share of Acme stock trading at 30, now consider the costs of buying and holding an Acme share that pays a dividend of $1 during the life of the forward contract. In this case, an arbitrageur can now borrow the present value of the dividend (discounted at Rf), and repay that loan when the dividend is received. The cost to buy and hold Acme stock with an annual dividend of $1 is $[30 - PV_0(1)]$ $(1.05) = 30(1.05) - 1$. This illustrates that *benefits of holding an asset decrease its no-arbitrage forward price.*

The no-arbitrage price of a forward on an asset that has both costs and benefits of holding the asset is simply $[S_0 + PV_0\ (\text{costs}) - PV_0(\text{benefit})](1 + Rf)^T$.

We can also describe these relationships when costs and benefits are expressed as continuously compounded rates of return. Recall from Quantitative Methods that given a stated annual rate of *r* with continuous compounding, the effective annual return is $e^r - 1$, and the relationships between present and future values of *S* for a 1-year period are $FV = Se^r$ and $PV = Se^{-r}$. For a period of *T* years, $FV = Se^{rT}$ and $PV = Se^{-rT}$. With continuous compounding the following relationships hold:

- With no costs or benefits of holding the underlying asset, the no-arbitrage price of a forward that settles at time *T* is S_0e^{rT}, where *r* is the stated annual risk-free rate with continuous compounding.
- With storage costs at a continuously compounded annual rate of *c*, the no-arbitrage forward price until time *T* is $S_0e^{(r+c)T}$.
- With benefits, such as a dividend yield, expressed at a continuously compounded annual rate of *b*, the no-arbitrage forward price is until time *T* is $S_0e^{(r+c-b)T}$.

EXAMPLE: No-arbitrage price with continuous compounding

Consider a stock index trading at 1,550 with a dividend yield of 1.3% (continuously compounded rate) when the risk-free rate is 3% (continuously compounded rate). Calculate the no-arbitrage 6-month forward price of the stock index.

Answer:

The no-arbitrage price of a long 6-month forward is $1{,}550 \times e^{(0.03 - 0.013)(0.5)} =$ 1,563.23.

Forward Contracts on Currencies

Recall from Economics that we defined the no-arbitrage price of a forward on a currency as the forward price that satisfies the equality:

$$\text{forward exchange rate (p/b)} = \frac{1 + \text{interest rate}_{\text{price currency}}}{1 + \text{interest rate}_{\text{base currency}}} \times \text{spot exchange rate}$$

We can use this no-arbitrage forward rate to examine how an arbitrage profit can be made when the exchange rate in a forward contract is greater or less than the no-arbitrage forward exchange rate. The forward exchange rate depends on the spot exchange rate and the *difference* between the interest rates on the base and price currencies.

Consider a situation at $t = 0$ where the risk-free rate in euros is 3%, the risk-free rate in U.S. dollars is 2%, and the current USD/EUR exchange rate is 1.10. We will examine the arbitrage transactions that establish this relationship by looking at the trades for an investor based in the United States that seeks to profit from the higher interest rate on euros. The investor borrows 100 USD for one year at 2%, exchanges the USD for euros, invests the euros for one year at 3%, and then exchanges the resulting euros for USD. At the end of one year the arbitrageur will have 100/1.10 × 1.03 = 93.64 euros and owe 100(1.02) = 102 USD.

As these transactions have no net cost, there should be no gain from this transaction relative to simply investing the USD for one year at 2%. If this is the case, the 93.64 euros should equal 102 USD. This is the case if the exchange rate at the end of the year is 102/93.64, which equals a USD/EUR exchange rate of 1.0893. This is the no-arbitrage forward rate. From the formula we saw in Economics we can arrive at the same solution by 1.10 × (1.02/1.03) = 1.0893.

If the arbitrageur has a forward contract to buy USD with a price of 1/1.0893 = 0.9180 euros, he can exchange the 93.64 euros for 93.64/0.9180 = 102 USD, which is the amount owed on the original loan of 100 USD. The depreciation of the euro in the forward price just offsets the higher euro interest, and the arbitrage transaction returns zero. With a forward exchange rate greater than 1.0893, the arbitrage would have a profit, and with a forward exchange rate less than 1.0893, an arbitrageur could profit from the opposite transactions.

If we convert the effective annual rates to equivalent stated annual rates with continuous compounding, we get $R_{USD} = \ln 1.02 = 1.98\%$ and $R_{EUR} = \ln 1.03 = 2.96\%$. In this case we can say: forward exchange rate = $1.10 \times e^{(0.0198 - 0.0296)} = 1.0893$.

MODULE QUIZ 69.1

1. Derivatives pricing models use the risk-free rate to discount future cash flows because these models:
   A. are based on portfolios with certain payoffs.
   B. assume that derivatives investors are risk-neutral.
   C. assume that risk can be eliminated by diversification.
2. Arbitrage prevents:
   A. market efficiency.

B. earning returns higher than the risk-free rate of return.
C. two assets with identical payoffs from selling at different prices.

3. The underlying asset of a derivative is *most likely* to have a convenience yield when the asset:
   A. is difficult to sell short.
   B. pays interest or dividends.
   C. must be stored and insured.
4. An investor can replicate a long forward on a stock that pays no dividends by:
   A. selling the underlying short and investing the proceeds at the risk-free rate.
   B. buying the underlying in the spot market and holding it.
   C. borrowing at the risk-free rate to buy the underlying.
5. The forward price of a commodity will *most likely* be equal to the current spot price if the:
   A. convenience yield equals the storage costs as a percentage.
   B. convenience yield is equal to the risk-free rate plus storage costs as a percentage.
   C. risk-free rate equals the storage costs as a percentage minus the convenience yield.

KEY CONCEPTS

LOS 69.a

Valuation of derivative securities is based on a no-arbitrage condition. When the forward price is too high, the arbitrage is to sell the forward and buy the underlying asset. When the forward price is too low, the arbitrage is to buy the forward and sell short the underlying asset. Arbitrage will move the forward price toward its no-arbitrage level.

Replication refers to creating a portfolio with cash market transactions that has the same payoffs as a derivative for all possible future values of the underlying. Replication allows us to calculate the no-arbitrage forward price of an asset.

LOS 69.b

Assuming no costs or benefits of holding the underlying asset, the forward price that will prevent arbitrage is the spot price compounded at the risk-free rate over the time until expiration.

The cost of carry is the benefits of holding the asset minus the costs of holding the asset.

Greater costs of holding an asset increase its no-arbitrage forward price.

Greater benefits of holding an asset decrease its no-arbitrage forward price.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 69.1

1. **A** Derivatives pricing models use the risk-free rate to discount future cash flows because they are based on arbitrage relationships that are theoretically riskless. (LOS 69.a)

2. **C** Arbitrage forces two assets with the same expected future value to sell for the same current price. (LOS 69.a)

3. **A** Convenience yield refers to nonmonetary benefits from holding an asset. One example of convenience yield is the advantage of owning an asset that is difficult to sell short when it is perceived to be overvalued. Interest and dividends are monetary benefits. Storage and insurance are carrying costs. (LOS 69.b)

4. **C** Borrowing S_0 at Rf to buy the underlying asset at S_0 has a zero cost and pays the spot price of the underlying asset minus the loan repayment of at time = T of $S_0(1 + Rf)^T$, which is the same payoff as a long forward at $F_0 = S_0(1 + Rf)^T$, the no-arbitrage forward price. (LOS 69.a)

5. **B** When the opportunity cost of funds (Rf) and storage costs just offset the benefits of holding the commodity, the no-arbitrage forward price is equal to the current spot price of the underlying commodity. (LOS 69.b)

READING 70

PRICING AND VALUATION OF FORWARD CONTRACTS AND FOR AN UNDERLYING WITH VARYING MATURITIES

MODULE 70.1: FORWARD CONTRACT VALUATION

Video covering this content is available online.

LOS 70.a: Explain how the value and price of a forward contract are determined at initiation, during the life of the contract, and at expiration.

Consider a forward contract that is initially priced at its no-arbitrage value of $F_0(T) = S_0(1 + Rf)^T$. At initiation, the value of such a forward is: $V_0(T) = S_0 - F_0(T)\,(1 + Rf)^{-T} = 0$.

At any time during its life, the value of the forward contract to the buyer will be $V_t(T) = S_t - F_0(T)\,(1 + Rf)^{-(T-t)}$. This is simply the current spot price of the asset minus the present value of the forward contract price.

This value can be realized by selling the asset short at S_t and investing $F_0(T)\,(1 + Rf)^{-(T-t)}$ in a pure discount bond at Rf. These transactions end any exposure to the forward; at settlement, the proceeds of the bond will cover the cost of the asset at the forward price, and the asset can be delivered to cover the short position.

At expiration, time *T*, the value of a forward to the buyer is $= S_T - F_0(T)(1 + Rf)^{-(T-T)} = S_T - F_0(T)$. The long buys an asset valued at S_T for the forward contract price of $F_0(T)$, gaining if $S_T > F_0(T)$, losing if $S_T < F_0(T)$. If the forward buyer has a gain, the forward seller has an equal loss, and vice versa.

In the more general case, when there are costs and benefits of holding the underlying asset, the value of a forward to the buyer at time $= t < T$ is:

$$V_t(T) = [S_t + PV_t\,(\text{costs}) - PV_t(\text{benefit})] - F_0(T)\,(1 + Rf)^{-(T-t)}$$

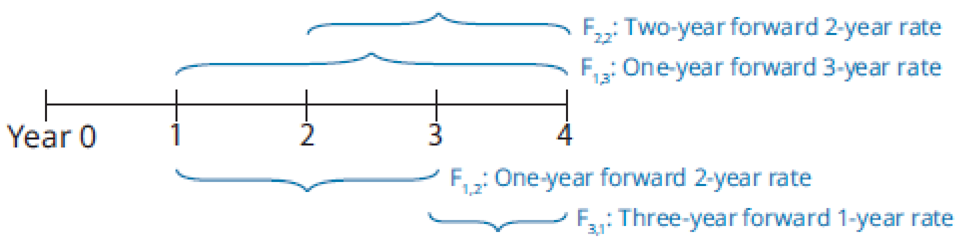
LOS 70.b: Explain how forward rates are determined for interest rate forward

contracts and describe the uses of these forward rates.

Forward rates are yields for future periods. The rate of interest on a 1-year loan to be made two years from today is a forward rate.

The notation for forward rates must identify both the length of the loan period and how far in the future the money will be loaned (or borrowed). 1y1y or $F_{1,1}$ is the rate for a 1-year loan one year from now; 2y1y or $F_{2,1}$ is the rate for a 1-year loan to be made two years from now; the 2-year forward rate three years from today is 3y2y or $F_{3,2}$; and so on.

Figure 70.1: Forward Rates



For money market rates the notation is similar, with 3m6m denoting a 6-month rate three months in the future.

Recall that spot rates are zero-coupon rates. We will denote the YTM (with annual compounding) on a zero-coupon bond maturing in *n* years as Z_n.

An **implied forward rate** is the forward rate for which the following two strategies have the same yield over the total period:

- Investing from $t = 0$ to the forward date, and rolling over the proceeds for the period of the forward.
- Investing from $t = 0$ until the end of the forward period.

As an example, lending for two years at Z_2 would produce the same ending value as lending for one year at Z_1 and, at $t = 1$, lending the proceeds of that loan for one year at $F_{1,1}$. That is, $(1 + Z_2)^2 = (1 + Z_1)(1 + F_{1,1})$. When this condition holds, $F_{1,1}$ is the implied (no-arbitrage) forward rate.

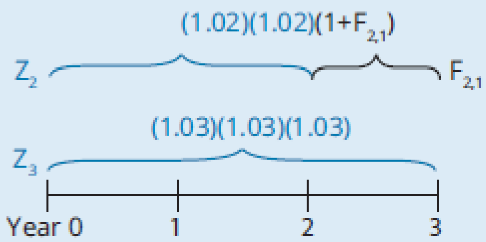
EXAMPLE: Implied forward rate

Consider two zero-coupon bonds, one that matures in two years and one that matures in three years, when $Z_2 = 2\%$ and $Z_3 = 3\%$. Calculate the implied 1-year forward rate two years from now, $F_{2,1}$.

Answer:

As illustrated in Figure 70.2, lending for three years at Z_3 should be equivalent to lending for two years at Z_2 and then for the third year at $F_{2,1}$.

Figure 70.2: Implied Forward Rate



Lending \$100 for two years at Z_2 (2%) results in a payment of $\$100(1.02)^2 = \$104.04$ at $t = 2$, while lending \$100 for three years at Z_3 (3%) results in a payment of $\$100(1.03)^3 = \$109.27$. The forward interest rate $F_{2,1}$ must be 109.27/104.04 – 1 = 5.03%, the implied forward rate from $t = 2$ to $t = 3$.

An example of an interest rate derivative is a **forward rate agreement (FRA)**, in which the fixed-rate payer (long) will pay the forward rate on a notional amount of principal at a future date, and the floating-rate payer will pay a future reference rate times that same amount of principal. In practice, only the net amount is exchanged.

Consider a 3-month forward on a 6-month MRR (F_{3m6m}) with a notional principal of \$1 million. At settlement in three months, the buyer receives (or pays) the present value of (realized 6-month MRR – 1%)/2 × \$1 million.

We divide by 2 because MRRs are typically annualized rates. We take the present value of the difference in interest because the settlement payment is at the beginning of the 6-month period, whereas the interest savings would be at the end of the period.

Assume that the current 3-month MRR is 1.0% and 9-month MRR is 1.2%. Adjusting for periodicity, the no-arbitrage condition for the value of F_{3m6m} is:

$$1 + 0.012\left(\frac{9}{12}\right) = \left[1 + 0.01\left(\frac{3}{12}\right)\right]\left[1 + F_{3m,6m}\left(\frac{6}{12}\right)\right]$$

The implied forward rate, F_{3m6m}, as an annualized rate, is:

$$F_{3m,6m} = \left[\frac{1 + 0.012\left(\frac{9}{12}\right)}{1 + 0.01\left(\frac{3}{12}\right)} - 1\right] \times \frac{12}{6} = 0.013$$

Now let's examine the payoff to the fixed-rate payer in an F_{3m6m} FRA with a notional principal of \$1 million when the 6-month MRR three months from now is 1.5%. Because the realized 6-month MRR is greater than the forward rate, the fixed-rate payer (floating-rate receiver) will have a gain.

The payment to the fixed-rate payer is the present value (discounted at 6-month MRR) of the interest differential between two 6-month loans, one at 1.3% and one at 1.5% (both annualized rates). The fixed-rate payer in the FRA receives:

$$\$1 \text{ million} \times \left(\frac{0.015 - 0.013}{2}\right)\left(\frac{1}{1 + (0.015/2)}\right) = \$992.56$$

FRAs are used primarily by financial institutions to manage the volatility of their interest-sensitive assets and liabilities. FRAs are also the building blocks of interest rate swaps over multiple periods. An FRA is equivalent to a single-period swap. Multiple-period swaps are used primarily by investors and issuers to manage interest rate risk.

MODULE QUIZ 70.1

1. Two parties agree to a forward contract to exchange 100 shares of a stock one year from now for $72 per share. Immediately after they initiate the contract, the price of the underlying stock increases to $74 per share. This share price increase represents a gain for:
   A. the buyer.
   B. the seller.
   C. neither the buyer nor the seller.
2. The forward rate 2y3y represents the interest rate on a loan period that begins:
   A. 2 years from now and ends 3 years from now.
   B. 2 years from now and ends 5 years from now.
   C. 3 years from now and ends 5 years from now.
3. Given zero-coupon bond yields for 1, 2, and 3 years, an analyst can *least likely* derive an implied:
   A. 1-year forward 1-year rate.
   B. 2-year forward 1-year rate.
   C. 2-year forward 2-year rate.

KEY CONCEPTS

LOS 70.a

The value of a forward contract at initiation is zero.

During its life, the value of a forward contract to the buyer is the spot price of the asset minus the present value of the forward contract price, and the value to the seller is the present value of the forward contract price minus the spot price of the asset.

At expiration, the value of a forward contract to the buyer is the spot price of the asset minus the forward contract price, and the value to the seller is the forward contract price minus the spot price of the asset.

LOS 70.b

An implied forward rate is the forward rate for which the following two strategies have the same yield over the total period:

- Investing from $t = 0$ to the forward date, and rolling over the proceeds for the period of the forward.
- Investing from $t = 0$ until the end of the forward period.

In a forward rate agreement (FRA), the fixed-rate payer (long) will pay the forward rate on a notional amount of principal at a future date, and the floating-rate payer will pay a future reference rate times that same amount of principal. FRAs are used primarily by financial institutions to manage the volatility of their interest-sensitive assets and liabilities.

ANSWER KEY FOR MODULE QUIZZES

Module Quiz 70.1

1. **A** If the value of the underlying is greater than the forward price, this increases the value of the forward contract, which represents a gain for the buyer and a loss for the seller. (LOS 70.a)
2. **B** 2y3y is the 2-year forward 3-year rate, covering a period that begins two years from now and extends for three years after that. (LOS 70.b)
3. **C** The forward rate $F_{2,2}$ extends four years into the future and cannot be derived using zero-coupon yields that only extend three years. From zero-coupon bond yields for 1, 2, and 3 years, we can derive implied forward rates $F_{1,1}$, $F_{1,2}$, and $F_{2,1}$. (LOS 70.b)