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Fixed Income, Derivatives, and Alternative Investments

Level II Book 4

KAPLAN SCHWESER

Book 4: Fixed Income, Derivatives, and Alternative Investments

SchweserNotes™ 2026

Level II CFA®

KAPLAN SCHWESER

SCHWESERNOTES™ 2026 LEVEL II CFA® BOOK 4: FIXED INCOME, DERIVATIVES, AND ALTERNATIVE INVESTMENTS

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READING 23

THE TERM STRUCTURE AND INTEREST RATE DYNAMICS

EXAM FOCUS

This topic review discusses the theories and implications of the term structure of interest rates. In addition to understanding the relationships between spot rates, forward rates, yield to maturity, and the shape of the yield curve, be sure you become familiar with concepts like the *Z*-spread, the TED spread and the MRR-OIS spread. Interpreting the shape of the yield curve in the context of the theories of the term structure of interest rates is always important for the exam. Also pay close attention to the concept of key rate duration.

INTRODUCTION

The financial markets both impact and are controlled by interest rates. Understanding the term structure of interest rates (i.e., the graph of interest rates at different maturities) is one key to understanding the performance of an economy. In this reading, we explain how and why the term structure changes over time.

Spot rates are the annualized market interest rates for a single payment to be received in the future. Generally, we use spot rates for government securities (risk-free) to generate the spot rate curve. Spot rates can be interpreted as the yields on zero-coupon bonds, and for this reason we sometimes refer to spot rates as *zero-coupon rates*. A **forward rate** is an interest rate (agreed to today) for a loan to be made at some future date.

PROFESSOR'S NOTE

While most of the LOS in this topic review have *describe* or *explain* as the command words, we will still delve into numerous calculations, as it is difficult to really understand some of these concepts without getting in to the mathematics behind them.

MODULE 23.1: SPOT AND FORWARD RATES, PART 1

LOS 23.a: Describe relationships among spot rates, forward rates, yield to maturity, expected and realized returns on bonds, and the shape of the yield curve.

Spot Rates

The price today of $1 par, zero-coupon bond is known as the discount factor, which we will call P_T. Because it is a zero-coupon bond, the spot interest rate is the yield to maturity of this payment, which we represent as S_T. The relationship between the discount factor P_T and the spot rate S_T for maturity T can be expressed as:

$$P_T = \frac{1}{(1 + S_T)^T}$$

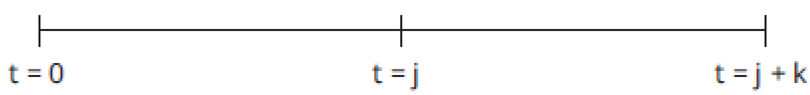
The term structure of spot rates—the graph of the spot rate S_T versus the maturity T—is known as the **spot yield curve** or **spot curve**. The shape and level of the spot curve changes continuously with the market prices of bonds.

Forward Rates

The annualized interest rate on a loan to be initiated at a future period is called the **forward rate** for that period. The term structure of forward rates is called the **forward curve**. (Note that forward curves and spot curves are mathematically related—we can derive one from the other.)

We will use the following notation:

$f(j,k)$ = the annualized interest rate applicable on a k-year loan starting in j years.



$F_{(j,k)}$ = the forward price of a $1 par zero-coupon bond maturing at time $j+k$ delivered at time j.

$$F_{(j,k)} = \frac{1}{[1 + f(j,k)]^k}$$

Yield to Maturity

As we've discussed, the **yield to maturity (YTM)** or yield of a zero-coupon bond with maturity T is the spot interest rate for a maturity of T. However, for a coupon bond, if the spot rate curve is not flat, the YTM will not be the same as the spot rate.

EXAMPLE: Spot rates and yield for a coupon bond

Compute the price and yield to maturity of a three-year, 4% annual-pay, $1,000 face value bond given the following spot rate curve: S_1 = 5%, S_2 = 6%, and S_3 = 7%.

Answer:

1. Calculate the price of the bond using the spot rate curve:

$$\text{Price} = \frac{40}{(1.05)} + \frac{40}{(1.06)^2} + \frac{1040}{(1.07)^3} = \$922.64$$

2. Calculate the yield to maturity (y_3):

N = 3; PV = –922.64; PMT = 40; FV = 1,000; CPT I/Y → 6.94
y_3 = 6.94%

Note that the yield on a three-year bond is a weighted average of three spot rates, so in this case we would expect $S_1 < y_3 < S_3$. The yield to maturity y_3 is closest to S_3 because the par value dominates the value of the bond and therefore S_3 has the highest weight.

Expected and Realized Returns on Bonds

Expected return is the ex-ante holding period return that a bond investor expects to earn.

The expected return will be equal to the bond's yield only when *all three* of the following are true:

- The bond is held to maturity.
- All payments (coupon and principal) are made on time and in full.
- All coupons are reinvested at the original YTM.

The second requirement implies that the bond is option-free and there is no default risk.

The last requirement, reinvesting coupons at the YTM, is the least realistic assumption. If the yield curve is not flat, the coupon payments will not be reinvested at the YTM and the expected return will differ from the yield.

Realized return on a bond refers to the actual return that the investor experiences over the investment's holding period. Realized return is based on actual reinvestment rates.

The Forward Pricing Model

The **forward pricing model** values forward contracts based on arbitrage-free pricing.

Consider two investors.

Investor A purchases a $1 face value, zero-coupon bond maturing in *j+k* years at a price of $P_{(j+k)}$.

Investor B enters into a *j*-year forward contract to purchase a $1 face value, zero-coupon bond maturing in *k* years at a price of $F_{(j,k)}$. Investor B's cost today is the present value of the cost: $PV[F_{(j,k)}]$ or $P_j F_{(j,k)}$.

Because the $1 cash flows at *j+k* are the same, these two investments should have the same price, which leads to the forward pricing model:

$$P_{(j+k)} = P_j F_{(j,k)}$$

Therefore:

$$F_{(j,k)} = \frac{P_{(j+k)}}{P_j}$$

EXAMPLE: Forward pricing

Calculate the forward price two years from now for a $1 par, zero-coupon, three-year bond given the following spot rates.

The two-year spot rate, S_2 = 4%.

The five-year spot rate, S_5 = 6%.

Answer:

Calculate discount factors P_j and $P_{(j+k)}$.

$$P_j = P_2 = 1 / (1 + 0.04)^2 = 0.9246$$
$$P_{(j+k)} = P_5 = 1 / (1 + 0.06)^5 = 0.7473$$

The forward price of a three-year bond in two years is represented as $F_{(2,3)}$

$$F_{(j,k)} = P_{(j+k)} / P_j$$
$$F_{(2,3)} = 0.7473 / 0.9246 = 0.8082$$

In other words, $0.8082 is the price agreed to today, to pay in two years, for a three-year bond that will pay $1 at maturity.

PROFESSOR'S NOTE

In the Derivatives portion of the curriculum, the forward price is computed as the future value (for *j* periods) of $P_{(j+k)}$. It gives the same result and can be verified using the data in the previous example by computing the future value of P_5 (i.e., compounding for two periods at S_2). FV = $0.7473(1.04)^2$ = $0.8082.

The Forward Rate Model

The **forward rate model** relates forward and spot rates as follows:

$$[1 + S_{(j+k)}]^{(j+k)} = (1 + S_j)^j [1 + f(j,k)]^k$$

or

$$[1 + f(j,k)]^k = [1 + S_{(j+k)}]^{(j+k)} / (1 + S_j)^j$$

This model is useful because it illustrates how forward rates and spot rates are interrelated.

This equation suggests that the forward rate $f(2,3)$ should make investors indifferent between buying a five-year zero-coupon bond versus buying a two-year zero-coupon bond and at maturity reinvesting the principal for three additional years.

EXAMPLE: Forward rates

Suppose that the two-year and five-year spot rates are $S_2 = 4\%$ and $S_5 = 6\%$.

Calculate the implied three-year forward rate for a loan starting two years from now [i.e., $f(2,3)$].

Answer:

$$[1 + f(j,k)]^k = [1 + S_{(j+k)}]^{(j+k)} / (1 + S_j)^j$$

$$[1 + f(2,3)]^3 = [1 + 0.06]^5 / [1 + 0.04]^2$$

$$f(2,3) = 7.35\%$$

Note that the forward rate $f(2,3) > S_5$ because the yield curve is upward sloping.

If the yield curve is upward sloping, [i.e., $S_{(j+k)} > S_j$], then the forward rate corresponding to the period from j to k [i.e., $f(j,k)$] will be greater than the spot rate for maturity $j+k$ [i.e., $S_{(j+k)}$]. The opposite is true if the curve is downward sloping.

LOS 23.b: Describe how zero-coupon rates (spot rates) may be obtained from the par curve by bootstrapping.

A **par rate** is the yield to maturity of a bond trading at par. Par rates for bonds with different maturities make up the **par rate curve** or simply the **par curve**. By definition, the par rate will be equal to the coupon rate on the bond. Generally, par curve refers to the par rates for government or benchmark bonds.

By using a process called **bootstrapping**, spot rates or zero-coupon rates can be derived from the par curve. Bootstrapping involves using the output of one step as an input to the next step. We first recognize that (for annual-pay bonds) the one-year spot rate (S_1) is the same as the one-year par rate. We can then compute S_2 using S_1 as one of the inputs. Continuing the process, we can compute the three-year spot rate S_3 using S_1 and S_2 computed earlier. Let's clarify this with an example.

EXAMPLE: Bootstrapping spot rates

Given the following (annual-pay) par curve, compute the corresponding spot rate curve:

Maturity	Par Rate
1	1.00%
2	1.25%
3	1.50%

Answer:

S_1 = 1.00% (given directly).

If we discount each cash flow of the bond using its yield, we get the market price of the bond. Here, the market price is the par value. Consider the 2-year bond.

$$100 = \frac{1.25}{(1.0125)} + \frac{101.25}{(1.0125)^2}$$

Alternatively, we can also value the 2-year bond using spot rates:

$$100 = \frac{1.25}{(1+S_1)} + \frac{101.25}{(1+S_2)^2} = \frac{1.25}{(1.01)} + \frac{101.25}{(1+S_2)^2}$$

$$100 = 1.2376 + \frac{101.25}{(1+S_2)^2}$$

$$98.7624 = \frac{101.25}{(1+S_2)^2}$$

Multiplying both sides by $[(1 + S_2)^2 / 98.7624]$, we get $(1 + S_2)^2 = 1.0252$.

Taking square roots, we get $(1 + S_2) = 1.01252$. $S_2 = 0.01252$ or 1.252%

Similarly,
$$100 = \frac{1.50}{(1+S_1)} + \frac{1.50}{(1+S_2)^2} + \frac{101.50}{(1+S_3)^3}$$

Using the values of S_1 and S_2 computed earlier,

$$100 = \frac{1.50}{(1.01)} + \frac{1.50}{(1.01252)^2} + \frac{101.50}{(1+S_3)^3}$$

$$100 = 2.9483 + \frac{101.50}{(1+S_3)^3}$$

$$97.0517 = \frac{101.50}{(1+S_3)^3}$$

$(1 + S_3)^3 = 1.0458$

$(1 + S_3) = 1.0151$ and hence $S_3 = 1.51\%$

MODULE QUIZ 23.1

1. When the yield curve is downward sloping, the forward curves are *most likely* to lie:
   A. above the spot curve.
   B. below the spot curve.
   C. either above or below the spot curve.

2. The model that equates buying a long-maturity zero-coupon bond to entering into a forward contract to buy a zero-coupon bond that matures at the same time is known as the:
   A. forward rate model.
   B. forward pricing model.

C. forward arbitrage model.

MODULE 23.2: SPOT AND FORWARD RATES, PART 2

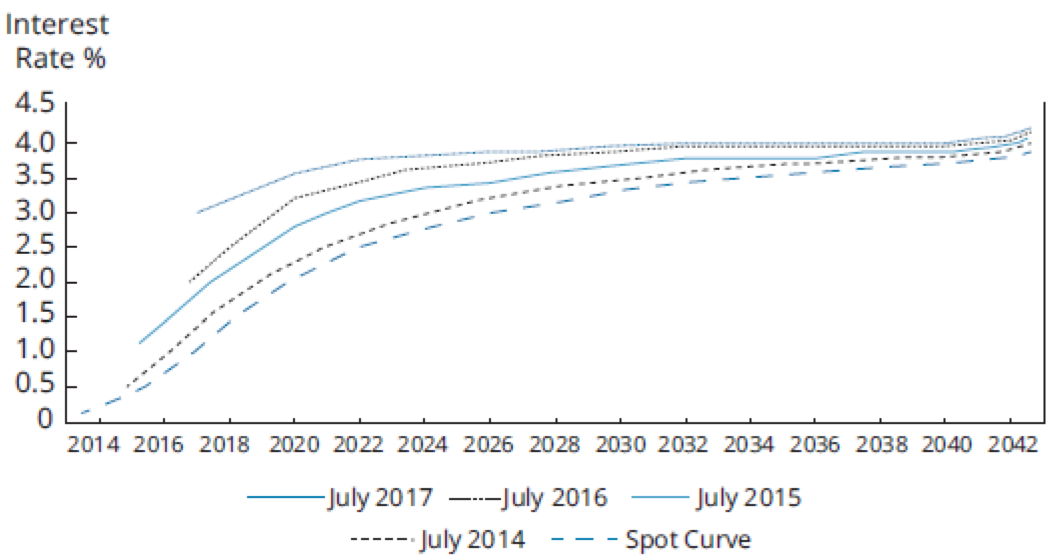
LOS 23.c: Describe the assumptions concerning the evolution of spot rates in relation to forward rates implicit in active bond portfolio management.

Relationships Between Spot and Forward Rates

For an upward-sloping spot curve, the forward rate rises as *j* increases. (For a downward-sloping yield curve, the forward rate declines as *j* increases.) For an upward-sloping spot curve, the forward curve will be above the spot curve as shown in Figure 23.1. Conversely, when the spot curve is downward sloping, the forward curve will be below it.

Figure 23.1 shows spot and forward curves as of July 2013. Because the spot yield curve is upward sloping, the forward curves lie above the spot curve.

Figure 23.1: Spot Curve and Forward Curves



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From the forward rate model:

$$(1 + S_T)^T = (1 + S_1)[1 + f(1,T - 1)]^{(T - 1)}$$

which can be expanded to:

$$(1 + S_T)^T = (1 + S_1)\,[1 + f(1,1)]\,[1 + f(2,1)]\,[1 + f(3,1)]\,....\,[1 + f(T - 1,1)]$$

In other words, the spot rate for a long-maturity security will equal the geometric mean of the one period spot rate and a series of one-year forward rates.

Forward Price Evolution

If the future spot rates actually evolve as forecasted by the forward curve, the forward price will remain unchanged. Therefore, a change in the forward price indicates that the future spot rate(s) did not conform to the forward curve. When spot rates turn out to be lower (higher) than implied by the forward curve, the forward price will increase (decrease). A trader expecting lower future spot rates (than implied by the current forward rates) would purchase the forward contract to profit from its appreciation.

For a bond investor, the return on a bond over a one-year horizon is always equal to the one-year risk-free rate *if the spot rates evolve as predicted by today's forward curve*. If the spot curve one year from today is not the same as that predicted by today's forward curve, the return over the one-year period will differ, with the return depending on the bond's maturity.

An active portfolio manager will try to outperform the overall bond market by predicting how the future spot rates will differ from those predicted by the current forward curve.

EXAMPLE: Spot rate evolution

Jane Dash, CFA, has collected benchmark spot rates as shown here:

Maturity	Spot Rate
1	3.00%
2	4.00%
3	5.00%

The expected spot rates at the end of one year are as follows:

Year	Expected Spot
1	5.01%
2	6.01%

Calculate the one-year holding period return of a:

1. 1-year zero-coupon bond.
2. 2-year zero-coupon bond.
3. 3-year zero-coupon bond.

Answer:

First, note that the expected spot rates provided just happen to be the forward rates implied by the current spot rate curve.

Recall that:

$$[1 + f(j,k)]^k = [1 + S_{(j+k)}]^{(j+k)} / (1 + S_j)^j$$

Hence:

$$[1 + f(1,1)]^1 = \frac{(1 + S_2)^2}{(1 + S_1)} = \frac{(1.04)^2}{(1.03)} \rightarrow f(1,1) = 0.0501 \text{ and}$$

$$[1 + f(1,2)]^2 = \frac{(1 + S_3)^3}{(1 + S_1)} = \frac{(1.05)^3}{(1.03)} \rightarrow f(1,2) = 0.0601$$