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Practical – Fix Income

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Content

A. Pricing a bond

B. Yield to maturity

C. Holding period returns

Pricing Zero Coupon Bonds — Example

Zero coupon bonds with a face value of $1,000

Fill in the price for each maturity and each yield

Maturity	r = 8%	r = 5%	r = 2%
T = 10			
T = 5			
T = 2			
T = 1			

Pricing Zero Coupon Bonds — Answer

Lower yields → higher prices

Longer maturity → lower prices

Maturity	r = 8%	r = 5%	r = 2%
T = 10	463.19	613.91	820.35
T = 5	680.58	783.53	905.73
T = 2	857.34	907.03	961.17
T = 1	925.93	952.38	980.39

Pricing by Decomposition — Example

A 3-year bond, face $1,000, annual coupon 6%, r = 5%

(a) Price a 3-year zero with the same face value

(b) What are the three $60 coupons worth today?

(c) What is the price of the coupon bond?

(d) Discount, par or premium — and why?

(e) Now set r = 6%. Predict before you compute

Pricing by Decomposition — Answer

(a) The zero: $1{,}000 / 1.05^3 = \$863.84$

(b) The coupons: $(60 / 0.05)[1 - 1/1.05^3] = \$163.39$

(c) $B = 863.84 + 163.39 = \$1{,}027.23$

(d) Premium: coupon 6% above the required return 5%

(e) At r = 6% the price is exactly $1,000 — par

A bond is an annuity plus a zero. No new formula

Valuing a Coupon Bond — Example

A $1,000 par, 2-year, 5% coupon bond, paid annually

Cash flows: $50 at t = 1, and $1,050 at t = 2

(a) Price it at a 5% yield. Guess before computing

(b) Price it at a 6% yield

Valuing a Coupon Bond — Answer

(a) $50 / 1.05 + 1{,}050 / 1.05^2 = 47.62 + 952.38 = \$1{,}000$

Coupon rate = yield, so it is worth par. No maths needed

(b) $50 / 1.06 + 1{,}050 / 1.06^2 = 47.17 + 934.50 = \$981.67$

Yield up one point, price down 1.83%

Yield to Maturity — Example

A 3-year annual-pay bond, coupon 8%, face $1,000

(a) Draw the cash-flow line

(b) If it sells at $1,000, what is the YTM?

The YTM is the rate that makes price = PV of cash flows

Yield to Maturity — Answer

Cash flows: \$80, \$80 and \$1,080

$1{,}000 = 80/(1+y) + 80/(1+y)^2 + 1{,}080/(1+y)^3 \rightarrow y = 8\%$

YTM = coupon rate = 8%: the bond trades at par

An average, not a promise: it assumes you hold and reinvest

Discount, Par and Premium — Example

The same bond: 3 years, coupon 8%, face $1,000

(a) If it sells at $1,000, what is the YTM?

(b) And if it sells at $900?

(c) And if it sells at $1,100?

(d) YTM above the coupon rate — what about the price?

Discount, Par and Premium — Answer

	Price	Coupon	Current Yield	YTM
Premium bond	1,100	8%	7.27%	4.35%
Par bond	1,000	8%	8%	8%
Discount bond	900	8%	8.88%	12.17%

YTM above the coupon rate → discount. Equal → par. Below → premium. It is arithmetic, not convention.

Semi-Annual Coupons — Example

Almost every real bond pays twice a year

Halve the coupon, halve the yield, double the periods

A 3-year bond, face $1,000, 8% semi-annual, quoted 6%

(a) What is its price?

(b) What is the effective annual yield?

Semi-Annual Coupons — Answer

Per period: coupon \$40, yield 3%, six periods

$B = 40 \times (1/0.03)[1 - 1/1.03^6] + 1{,}000/1.03^6 = \$1{,}054.17$

$EAR = 1.03^2 - 1 = 6.09\%$, not 6%

Quoted 6% annual-pay, the same bond is worth \$1,053.46

A quoted bond yield is an APR, not an EAR

Price, Coupon and Yield — Example

3-year annual-pay bonds, face $1,000

Fill in each price, and the change against the 8% column

	4% YTM	8% YTM	12% YTM
4% coupon			
% change			
8% coupon			
% change			
12% coupon			
% change			

Price, Coupon and Yield — Answer

Rates up, prices down — the iron law of fixed income

And every bond moves, whatever its coupon

	4% YTM	8% YTM	12% YTM
4% coupon	1,000.00	896.91	807.85
% change	11.5%	0.0%	−9.9%
8% coupon	1,111.00	1,000.00	903.93
% change	11.1%	0.0%	−9.6%
12% coupon	1,222.01	1,103.08	1,000.00
% change	10.8%	0.0%	−9.3%

HPR on a Zero Held to Maturity — Example

A 3-year zero, face $100, yield to maturity 5%

(a) What is its price today?

(b) Held to maturity, what is your holding period return?

(c) What is the annualised holding period return?

HPR on a Zero Held to Maturity — Answer

(a) Price = 100 / 1.05^3 = \$86.38

(b) HPR = 100 / 86.38 − 1 = 15.76% over three years

(c) Annualised: (1.1576)^(1/3) − 1 = 5.00% = the YTM

No coupons to reinvest, so nothing can go wrong

HPR on a Zero Sold Early — Example

A 3-year zero, face $1,000, current YTM 5%

(a) What is its price today?

One year later two years remain, and the YTM is 7%

(b) What is the price now?

(c) What was your realised return over the year?

(d) And if the YTM had stayed at 5%?

HPR on a Zero Sold Early — Answer

$P_0 = 1{,}000 / 1.05^3 = \$863.84$

At 7%: $P_1 = 1{,}000 / 1.07^2 = \$873.44 \rightarrow$ return 1.11%

At 5%: $P_1 = 1{,}000 / 1.05^2 = \$907.03 \rightarrow$ return 5.00%

You bought a 5% yield and earned 1.11%

Sell early and your return is the market's opinion that day

HPR on a Coupon Bond — Example

A 4-year bond, face $1,000, coupons $80, YTM 8%

(a) What is its price today?

(b) Its future value if coupons are reinvested at 8%?

(c) What is the annual return?

(d) And if rates fall to 4% next year?

HPR on a Coupon Bond — Answer

Price = $1,000: coupon rate equals YTM, so it is at par

Reinvested at 8%: FV = 80 × 4.5061 + 1,000 = $1,360.49

Return = (1,360.49 / 1,000)^(1/4) − 1 = 8.00% = the YTM

At 4%: FV = 339.72 + 1,000 = $1,339.72, return 7.59%

Nothing defaulted. That gap is reinvestment risk

Formulas

Zero coupon bond: $P = F / (1 + r)^T$

Coupon bond: $B = (C / r)[1 - 1/(1 + r)^T] + F / (1 + r)^T$

Semi-annual: halve C and y, double the periods

$EAR = (1 + y/2)^2 - 1$

$HPR = V_t / V_0 - 1$, annualised $(1 + HPR)^{(1/T)} - 1$

Current yield = annual coupon / price

Thanks