CALLABLE AND PUTABLE BONDS

- Introduction to options
- Introduction to bonds with embedded options
- Gains/losses from calling a bond
- Pricing
- Returns
- Duration and convexity

1

2

INTRODUCTION TO OPTIONS

2

OPTIONS

- What is an option?
  - A derivative security that gives the holder the right (but not the obligation) to buy or sell the underlying instrument at a pre-specified price by a pre-specified date
  - The option buyer pays the option seller for the option at the time the contract is agreed upon. The price is called the option price or option premium
- Option to buy underlying security = call option
- Option to sell underlying security = put option

3

OPTIONS (CONT.)

- What can you do with an option?
  - Exercise
  - Allow to expire
  - Trade
- Four features characterize an option
  - Underlying security
  - Exercise (or strike) price
  - Expiration date
  - Exercise commencement date

4

PAYOFF AND PROFIT DIAGRAMS

- Payoff diagrams provide a useful way of graphing payoffs to a security (especially a derivative security) at one point in time
  - These diagrams aid in replicating and valuing derivative securities
  - The graph plots the payoff of one security (the derivative) as a function of the payoff of another security (the original or underlying security)
- Profit diagrams
  - Profit = Payoff +/- Option's price

5

PAYOFF AND PROFIT DIAGRAMS: EXAMPLES

- Assume:
  - The current price of a bond, P_0, is \$100
  - We examine all payoffs at some point in time t = T
  - The value of underlying security at T is P_T
  - A call option with exercise price of \$101 at time T
  - A put option with exercise price of \$101 at time T
  - Both the call option and the put option currently cost \$1
- Plot the payoff diagram for buying the call, buying the put, selling the call or selling the put
- Plot the profit diagrams for the same positions

6

OPTION PAYOFF/PROFIT EXAMPLE

Consider a call option on bond X with an exercise price of $112 that expires in 3 months. Today the option's price is $4.

- What is your payoff if you buy the option today and in 3 months bond X is selling for $100? What is your profit/loss?
- What is your payoff if you sell the option and in 3 months bond X is selling for $100? What is your profit/loss?
- What is your payoff if you buy the option and in 3 months bond X is selling for $120? What is your profit/loss?

7

8 INTRODUCTION TO BONDS WITH EMBEDDED OPTIONS

8

BONDS WITH EMBEDDED OPTIONS

- Bonds with an option-like feature embedded into the contract:
  - Callable bonds
  - Putable bonds
  - Convertible bonds

9

CALLABLE BONDS: DEFINITIONS

- A call provision gives the issuer the right to buy back all or part of the issue at a pre-specified price before scheduled maturity
- Traditional call and refunding provisions
  - Call price/ Call schedule
  - Deferred call, call protection, first call date
  - Refunding restriction
    - Bonds can be callable but nonrefundable
- Make-whole call
  - Call price is the PV of remaining cash flows discounted at a rate of maturity-matched Treasury yield plus a small spread

10

PUTABLE BONDS: DEFINITION

- A put provision gives the bondholder the right to sell back the bond at a pre-specified price on designated dates

11

YIELD MEASURES

- For callable/putable bonds, the yield to maturity provides insufficient information
- Yield to call
  - Yield to first call or yield to next call, yield to first par call, yield to refunding
- Yield to put
  - Interest rate that makes the present value of the cash flows to the put date plus the put price on that date equal the bond's price
- Yield to worst
  - Lowest of YTM, yield to every possible call date and yield to every possible put date

12

YIELD MEASURES: EXAMPLE 1

Consider an 18-year 11% coupon bond with $1,000 par selling for $1,169 (semi-annual coupons). The first call date is 8 years from today and the call price is $1,055. What is the bond's yield to maturity (semiannual BEY)?

- What is the bond's yield to first call?
- Suppose that the first par call for this bond is 13 years from now. What is the bond's yield to first par call?
- Assume that the bond is putable at par in 5 years. What is the bond's yield to put?
- If the call/put dates above are the only ones, what is the bond's yield to worst?

13

14 GAINS AND LOSSES FROM CALLING A BOND

14

GAINS AND LOSSES FROM CALLING

- An issuer will call a callable bond if doing so results in a gain.
  - Compare the present value of the liability to the call price
    - The issue will not be called when rates rise since this increases the firm's liability
    - The issue might be called when rates fall since this decreases the firm's liability
      - Account for transaction costs
      - Remember that the call price is not simply the par value – it may include a premium
      - Waiting to call is expensive

15

GAINS AND LOSSES FROM CALLING: EXAMPLE 2

Consider a bond with the following characteristics: 30 years to maturity, 12% coupon rate, interest paid semi-annually, $1000 par value, $1050 call price, and no call protection. If rates fall to 11.5% will the company gain from calling the bond? Assume that there were no transaction costs.

16

GAINS AND LOSSES FROM CALLING: EXAMPLE 3

Consider a bond with the following characteristics: 30 years to maturity, 12% coupon rate, interest paid semi-annually, $1000 par value, $1050 call price, and no call protection. If rates fall to 9% will the company gain from calling the bond? Assume that there were no transaction costs.

- What if by calling the bond the company incurred transaction costs of $200 per bond? Would it still call the bond?

17

GAINS AND LOSSES FROM CALLING: EXAMPLE 3 (CONT.)

- Describe the actions that the issuer will undertake in order to take advantage of the new rates?
  - Issue new bonds at 9% to raise proceeds for calling the issue.
  - Since these bonds will be selling at par, one bond will give you $1000, but you need $1050.
  - Hence, you issue 1.05 new bonds for every bond you want to retire.
  - Use the $1050 dollars to call each $1000 par value bond.
- Where does the benefit/gain come from?

18

GAINS AND LOSSES FROM CALLING: EXAMPLE 3 (CONT.)

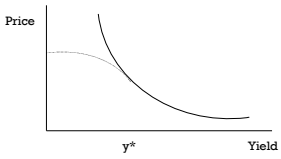
You believe that interest rates will fall even more to 8.9% next year. Will you call the issue today or wait until next year?

19

CALLABLE BONDS: THE BONDHOLDERS' PERSPECTIVE

In the previous example we calculated the gain to the issuing company from calling the bond. What is the effect on bondholders?

- Reinvestment risk
- Price compression



20

21 PRICING CALLABLE BONDS

21

EMBEDDED OPTION CHARACTERISTICS

- Purchasing a callable bond is equivalent to purchasing a non-callable bond and selling a call option on it.
- Purchasing a putable bond is equivalent to purchasing a non-callable bond and buying a put option on it.
- What characterizes the embedded option?
  1. Underlying asset?
  2. Exercise/strike price?
  3. Expiration date?
  4. Exercise commencement date?

22

PRICING CALLABLE BONDS

- Price of Callable Bond = Price of Non-callable Bond - Price of Call Option
  - How does the price of a callable bond compare to that of a straight bond with the same characteristics?
  - How does the yield of a callable bond compare to that of a straight bond with the same characteristics?

23

PRICING CALLABLE BONDS: BLACK-SCHOLES OPTION PRICING FORMULA

- We can price callable bonds, using B-S or any other option-pricing formula
  - Calculate the price of a straight bond with the same characteristics as the callable bond
  - Calculate the price of a call option on the straight bond
    - What do we need to know to price this call option?

24

BLACK-SCHOLES MODEL

$$C_0 = P_0 N(d_1) - Xe^{-r_f T} N(d_2)$$

where

$$d_1 = \frac{\ln(P_0 / X) + r_f T}{\sigma\sqrt{T}} + \frac{1}{2}\sigma\sqrt{T}$$

$$d_2 = d_1 - \sigma\sqrt{T}$$

N is the cumulative density function of a standard normal distributi on

σ is the standard deviation of the bond price

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25

LIMITATIONS OF USING B-S TO PRICE BOND OPTIONS

- Log-normal distribution of prices
- Constant volatility
- Interest rate changes are independent of the price of the underlying

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26

SWITCHING TO ANNUAL COUPON BONDS AND PERIODICITY OF 1 NOW TO MAKE THINGS SIMPLER…

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27

BINOMIAL OPTION PRICING

- Roadmap to pricing callable/putable bonds
  1. When is the bond going to be called/put?
  2. Keeping in mind when the bond is going to be called/put, what are the bond's promised cash flows?
  3. What is the present value of these cash flows?
  4. Accounting for the probability of receiving these cash flows, what is the bond's price?

28

BINOMIAL OPTION PRICING OF A CALLABLE BOND: EXAMPLE 4

The term structure of interest rates is flat at 10%, but rates could change immediately to 12% or 8% with equal probability and stay at that level forever. You purchase a callable bond with 30 years to maturity and 10% coupon paid annually. What should be the price of the callable bond, if it can be called immediately at $105?

29

BINOMIAL OPTION PRICING OF A CALLABLE BOND: EXAMPLE 4 (CONT.)

- What is the value of the call option embedded in the callable bond?
- What is the callable bond's spread over the yield of an otherwise identical non-callable bond?

30

BINOMIAL OPTION PRICING OF A CALLABLE BOND: EXAMPLE 5

The term structure of interest rates is flat at 10%, but rates could change immediately to 12% or 8% with equal probability and stay at that level forever. You purchase a callable bond with 30 years to maturity and 10% coupon paid annually. What should be the price of the callable bond, if it has a call price of $105 and call protection of 5 years?

31

PRICING PUTABLE BONDS

- Pricing principle is similar to the one used to price callable bonds
- Price of Putable Bond = Price of Non-putable Bond + Price of Put Option
  - A putable bond's price versus that of a straight bond with the same characteristics?
  - A putable bond's yield versus that of a straight bond with the same characteristics?
- Again, binomial option pricing works better than B-S option pricing formula

32

BINOMIAL OPTION PRICING OF A PUTABLE BOND: EXAMPLE 6

The term structure of interest rates is flat at 10%, but rates could change immediately to 12% or 8% with equal probability and stay at that level forever. You purchase a putable bond with 30 years to maturity and 10% coupon paid annually. What should be the price of the bond, if it can be put immediately at par?

33

34 RETURNS

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34

CALLABLE BONDS: RETURNS

- How do the expected returns of callable and non-callable bonds compare?
- Example 7A: Calculate 1-yr expected return for a straight and callable bond with the following characteristics (these are the bonds from Examples 4-5)
  - Rates are expected to immediately change to 12% or 8% with equal probability, and when they change they will stay at that level forever.
  - At purchase, the straight bond has 30 years to maturity, 10% coupon paid annually, $100 par value and price of $103.1366. [See Example 5]
  - At purchase, the callable bond has 30 years to maturity, 10% coupon paid annually, $100 par value, is callable at $105 and it has call protection of 5 years. Its price is $97.639. [See Example 4]

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35

CALLABLE BONDS: RETURNS

- How do the realized returns of callable and non-callable bonds compare?
- Example 7B: Calculate the two bonds' realized returns.
  - Non-callable bond
    - If rates are 12%
    - If rates are 8%
  - Callable bond
    - If rates are 12%
    - If rates are 8%

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36

37

DURATION AND CONVEXITY

37

CALLABLE BONDS: DURATION

- If we calculate the Macaulay duration of the straight and callable bond, how would their durations compare?
- What can we say about the price sensitivity of the bonds?
  - To remind you, in Examples 4-5 we calculate their prices when rates are 8% or 12%.

	10%	8%	12%
Non-callable bond	100	122.52	83.89
Callable bond (5yr call protection)	100	111.39	83.89

38

CALLABLE BONDS: DURATION

- For fixed-income securities whose cash flows depend on the level of interest rates, we estimate effective duration. The effective duration is simply the estimated price change for a given change in interest rates.

$$\text{Effective duration} = \frac{P_- - P_+}{2P_0(\Delta y)}$$

- Which bond is affected more by a given change in interest rates?
- What does this imply about the effective duration of straight and callable bonds?

39

CALLABLE BOND DURATION: EXAMPLE 8A

Calculate the effective convexity of the callable bond (with 5 years of call protection) and the otherwise similar non-callable bond we previously priced

- Let's use the numbers we calculated in Examples 4-5

	10%	8%	12%
Non-callable bond	100	122.52	83.89
Callable bond (5yr call protection)	100	111.39	83.89

40

CALLABLE BONDS: CONVEXITY

- Effective convexity similarly accounts for the change in cash flows when interest rates change:

$$\text{Effective convexity} = \frac{P_- + P_+ - 2P_0}{P_0(\Delta y)^2}$$

41

CALLABLE BONDS CONVEXITY: EXAMPLE 8B

Calculate the effective duration of the callable bond (with 5 years of call protection) and the otherwise similar non-callable bond we previously priced.

- Let's use the numbers we calculated in Examples 4-5

	10%	8%	12%
Non-callable bond	100	122.52	83.89
Callable bond (5yr call protection)	100	111.39	83.89

42