Options (1)

Class 19
Financial Management, 15.414
Today

Options

• Risk management: Why, how, and what?

• Option payoffs

Reading

• Brealey and Myers, Chapter 20, 21

• Sally Jameson
Types of questions

➢ Your company, based in the U.S., supplies machine tools to manufacturers in Germany and Brazil. Prices are quoted in each country’s currency, so fluctuations in the € / $ and R / $ exchange rate have a big impact on the firm’s revenues. How can the firm hedge these risks? Should it?

➢ Your firm is thinking about issuing 10-year convertible bonds. In the past, the firm has issued straight debt with a yield-to-maturity of 8.2%. If the new bonds are convertible into 20 shares of stocks, per $1,000 face value, what interest rate will the firm have to pay on the bonds? Why?

➢ You have the opportunity to purchase a mine that contains 1 million kgs of copper. Copper has a price of $2.2 / kg, mining costs are $2 / kg, and you have the option to delay extraction one year. How much is the mine worth?
Exchange rates, 1995 – 2003

- Real / $ (left scale)
- Euro / $ (right scale)
Example

Caterpillar

➢ Global leader, construction and mining equipment
  Sales in nearly 200 countries

➢ In 1980s, dollar up, then down 50%

<table>
<thead>
<tr>
<th>Year</th>
<th>1980</th>
<th>1984</th>
<th>1988</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales</td>
<td>$8,598</td>
<td>$6,576</td>
<td>$10,435</td>
</tr>
<tr>
<td>Net income</td>
<td>565</td>
<td>-428</td>
<td>616</td>
</tr>
<tr>
<td>Cap exp</td>
<td>749</td>
<td>234</td>
<td>793</td>
</tr>
</tbody>
</table>

$ millions
$ exchange rate, 1980 – 2000

Trade-weighted exchange rate
Risk management

What is the goal?

How can firms create value through risk management?

➢ View 1: Hedging is irrelevant (M&M)

   Purely financial transaction
   Diversified shareholders don’t care about firm-specific risks

➢ View 2: Hedging creates value

   Helps ensure that cash is available for positive NPV investments
   Reduces dependence on external finance
   Reduces probability of financial distress
   Improves performance evaluation and compensation
   Other benefits: reduce taxes, undiversified shareholders
Why hedge?

Three gold producers

- **Homestake Mining**
  Does not hedge because “shareholders will achieve maximum benefit from such a policy.”

- **American Barrick**
  Hedges aggressively to give the company “extraordinary financial stability… offering investors a predictable, rising earnings profile in the future.”

- **Battle Mountain Gold**
  Hedges up to 25% because “a recent study indicates that there may be a premium for hedging.”
Derivative use

Evidence

➢ Random sample of 413 large firms

Average cashflow from operations = $735 million
Average PP&E = $454 million
Average net income = $318 million

➢ How much hedging?

57% of firms use derivatives in 1997

For derivative users, if 3σ event, then cashflows up by $15 million and market value up by $31 million
Financial derivatives

➢ Options

Gives the holder the right to buy (call option) or sell (put option) an asset at a specified price.

Buyer has the choice

➢ Forwards and futures

A contract to exchange an asset in the future at a specified price and time.

Obligation for both

➢ Swaps

An agreement to exchange a series of cashflows at specified prices and times.

Obligation for both
Financial derivatives

Assets

➤ Financial assets
Stocks, bonds, stock indices, T Bonds (interest rates), foreign exchange

➤ Commodities
Oil, gold, silver, corn, soybeans, OJ, pork bellies, coffee

➤ Other events and prices
Electricity, weather, etc.

➤ Imbedded options
Convertible bonds, warrants, real options, mortgages
Futures contract

On Thursday, the NYM traded natural gas futures with delivery in August 2004 at a price of 4.900 $ / MMBtu.

➢ Buyer has a ‘long’ position
  Wins if prices go up

➢ Seller has a ‘short’ position
  Wins if prices go down

➢ The price of the contract is zero
  No cash changes hands today
Futures contract: Payoff diagram

Long position (buy)  - - - Short position (sell)

Gas price, Aug04
Option contract

Thursday, the CBOE traded 4,258 call option contracts (100 shares each) on Cisco stock with a strike price of $20.00 and an expiration date in October. The option price is $0.30.

➢ Buyer has the right to buy Cisco at $20
  Option will be exercised if Cisco > $20

➢ Seller is said to ‘write’ the option

➢ American options can be exercised anytime on or before the maturity date.

➢ European options can be exercised only on the maturity date.

➢ Out of the money if the stock price is lower than the strike price.
  In the money if the stock price is greater than the strike price.
WSJ option quotes

<table>
<thead>
<tr>
<th>Option/Strike</th>
<th>Exp</th>
<th>Call</th>
<th>Put</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Vol</td>
<td>Last</td>
</tr>
<tr>
<td>Cisco</td>
<td>15</td>
<td>Jan</td>
<td>4128</td>
</tr>
<tr>
<td>17.83</td>
<td>Aug</td>
<td>5307</td>
<td>0.40</td>
</tr>
<tr>
<td>17.83</td>
<td>Oct</td>
<td>4258</td>
<td>0.30</td>
</tr>
</tbody>
</table>

Stock price  Call price  Put price
Buy a call  
Strike price = $20

Payoff = max(0, S - X)
Option payoffs (strike = $50)

Buy a call

Sell a call

Buy a put

Sell a put
## Options

### Option payoffs

Asset price = $S$, strike price = $X$

**Buyer of the option**

<table>
<thead>
<tr>
<th></th>
<th>$S &lt; X$</th>
<th>$S &gt; X$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Call</td>
<td>0</td>
<td>$S - X$</td>
</tr>
<tr>
<td>Put</td>
<td>$X - S$</td>
<td>0</td>
</tr>
</tbody>
</table>

Risky if used alone
Stock price = $50
Call option, strike = $50 with 1-year to expiration

Stock return

Option return
Price ≈ $9
Option strategies

Financial engineering

Options can be mixed in various ways to create an unlimited number of payoff profiles.

Examples

- Buy a stock and a put
- Buy a call with one strike price and sell a call with another
- Buy a call and a put with the same strike price
Option strategies: Stock + put

- **Buy stock**
  - As the stock price increases, the profit increases linearly.

- **Buy put**
  - As the stock price increases, the profit decreases linearly.

- **Stock + put**
  - The combined strategy has a profit function that depends on both the stock price and the put option price.
Option strategies: $Call_1 - call_2$

- **Buy call with** $X = 50$
- **Write call with** $X = 60$

$call_1 - call_2$
Option strategies: Call + Put

Buy call with $X = 50$

Buy put with $X = 50$

Call + put
Option pricing

What is an option worth?

How can we estimate the expected cashflows?
How risky is an option? What is the appropriate discount rate?

Two formulas to know

- Put-call parity
- Black-Scholes formula
Put-call parity

Relation between put and call prices

\[ P + S = C + PV(X) \]

- \( S \) = stock price
- \( P \) = put price
- \( C \) = call price
- \( X \) = strike price
- \( PV(X) \) = present value of \( $X = X / (1+r)^t \)
- \( r \) = riskfree rate
Option strategies: Stock + put

- **Buy stock**: Gain increases as stock price increases.
- **Buy put**: Loss increases as stock price decreases.
- **Stock + put**: Gain increases as stock price increases, with a break-even point at the strike price. Loss increases as stock price decreases beyond the strike price.
Option strategies: Tbill + call

- Buy Tbill with FV = 50
- Buy call
- Tbill + call
Example

On Thursday, call options on Cisco stock with an expiration date in October and a strike price of $20 sold for $0.30. The current price of Cisco is $17.83. How much should put options with the same strike price and expiration date sell for?

Put-call parity

\[ P = C + PV(X) - S \]

\[ C = $0.30, \quad S = $17.83, \quad X = $20.00 \]

\[ r = 1\% \text{ annually} \rightarrow 0.15\% \text{ over the life of the option} \]

Put option \( = 0.30 + \frac{20}{1.0015} - 17.83 = \$2.44 \)

(WSJ price = $2.60)
Option pricing

Factors affecting option prices

Option prices depend on $S$, $X$, $T$, $\sigma^2$, $r$, $D$

<table>
<thead>
<tr>
<th></th>
<th>Call option</th>
<th>Put option</th>
</tr>
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<tbody>
<tr>
<td>Stock price ($S$)</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>Exercise price ($X$)</td>
<td>–</td>
<td>+</td>
</tr>
<tr>
<td>Time-to-maturity ($T$)</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Stock volatility ($\sigma$)</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Interest rate ($r$)</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>Dividends ($D$)</td>
<td>–</td>
<td>+</td>
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