The Economics of Money, Banking, and Financial Markets

FN 211 Financial Markets

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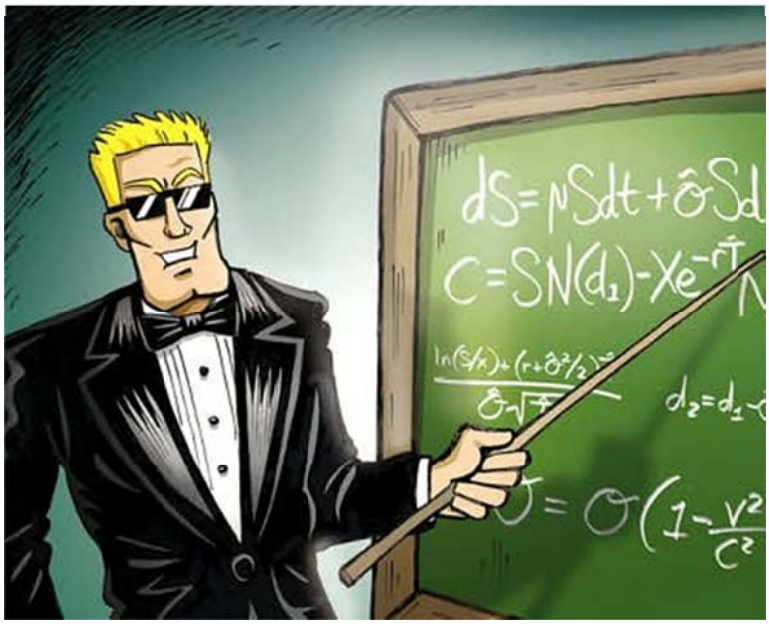
Derivatives Market: Option Contract



Options

- A call option is an option to buy a certain asset by a certain date for a certain price (the strike price)
- A put option is an option to sell a certain asset by a certain date for a certain price (the strike price)

Underlying Assets

Underlying Assets: Asset that option holder has right to buy (sell)

- Financial Options
  - Stock options
  - Stock index options
  - Foreign currency options
  - Interest rate options
  - Futures options
- Commodity options
  - Oil, gold, wheat, soybeans
  - Other types of options
  - Electricity, various sources of energy, weather

PRICES AT CLOSE JANUARY 02, 2008

I B M (IBM) — Underlying stock price: 104.69

		Call			Put		
Expiration	Strike	Last	Volume	Open Interest	Last	Volume	Open Interest
Jul	90	...	...	391	3.00	211	1312
Jan	95	10.40	347	16616	0.50	1539	11122
Feb	95	12.70	43	18	1.25	181	854
Apr	95	13.20	12	1183	2.75	59	2016
Jul	95	15.30	2	645	4.35	155	3744
Jan	100	6.00	205	11733	1.25	7860	26999
Feb	100	7.65	85	186	2.53	602	639
Apr	100	9.60	76	1476	4.30	413	9073
Jul	100	11.75	102	621	5.40	115	2554
Jan	105	3.10	1597	11706	3.20	3703	25885
Feb	105	4.40	401	433	4.40	448	692
Apr	105	7.00	152	1718	6.40	79	2361
Jul	105	9.00	33	686	8.10	66	1051
Jan	110	1.10	1775	17423	6.20	700	25999
Feb	110	2.30	472	474	7.40	28	3734
Apr	110	4.50	144	3950	9.10	115	4362
Jul	110	6.60	122	1045	10.50	99	770

FIGURE 20.1 Stock options on IBM

Source: *The Wall Street Journal Online*, January 3, 2008.

Options Terminology

- **Exercise Price / Strike Price**
  - Agreed price to buy (to sell)
- **Premium**
  - Price of the option
- **Expiration Date / Time-to-Expiration**
  - Life of the option
  - Time period that the option can be exercised

American vs European Options

- An American option can be exercised at any time during its life
- A European option can be exercised only at maturity

Options vs Futures/Forwards

- A futures/forward contract gives the holder the obligation to buy or sell at a certain price
- An option gives the holder the right to buy or sell at a certain price

Option Positions

- **Right**
  - Long call options [right to buy]
  - Long put options [right to sell]

- **Obligation**
  - Short call options [obligation to sell]
  - Short put options [obligation to buy]

Moneyness

In the Money:

- **exercise of the option would be profitable**

Call: market price>exercise price **Put: exercise price>market price**

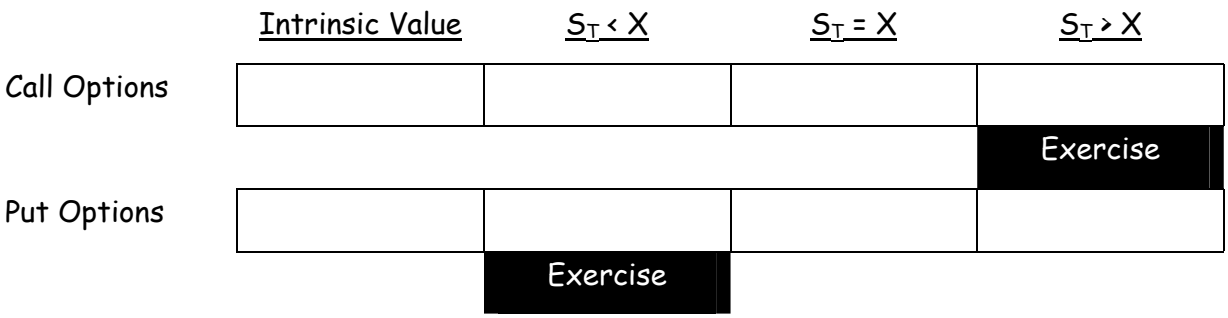
Out of the Money:

- **exercise of the option would not be profitable**

Call: market price<exercise price **Put: exercise price<market price**

At the Money:

- **exercise price and asset price are equal**



Payoff Diagram: Long Call Options

- Payoff from buying one European call option: option price = $5, strike price = $100, option life = 3 months

Spot Price										
Moneyness										
Net Payoff										

Payoff Diagram: Short Call Options

- Payoff from selling one European call option: option price = $5, strike price = $100, option life = 3 months

Spot Price										
Moneyness										
Net Payoff										

Payoff Diagram: Long Put Options

- Payoff from buying one European put option: option price = $5, strike price = $100, option life = 3 months

Spot Price										
Moneyness										
Net Payoff										

Payoff Diagram: Short Put Options

- Payoff from selling one European put option: option price = $5, strike price = $100, option life = 3 months

Spot Price										
Moneyness										
Net Payoff										

Exercise: Call Options and Put Options

Graph payoff diagrams of the following

- Call options with exercise price of $80, $5 premium
- Put options with exercise price of $80, $4 premium

Option Strategies

Bull Spread

- Bull spread utilises call options requires two calls or two puts with the same underlying stock and the same expiration date, but with different exercise prices.
- Trader of a bull spread buys a call with an exercise price below the stock price and sells a call option with an exercise price above the stock price.
- Trader of a bull spread buys a put with a lower exercise price and sells a put with higher exercise price.

Example

- Call option with $95 exercise price and traded at $7
- Call option with $105 exercise price and traded at $3

Example

- Put option with $90 exercise price and traded at $3
- Put option with $110 exercise price and traded at $9

Bear Spread

- Bear Spread is a combination of two call options or two put options with the same underlying stock and the same expiration date.
- Trader of a bear spread sells the call with a lower exercise price and buys the call with higher exercise price.
- Trader of a bear spread sells the put with a lower exercise price and buys the put with a higher exercise price.

Example

- Call option with $95 exercise price and traded at $7
- Call option with $105 exercise price and traded at $3

Example

- Put option with $90 exercise price and traded at $3
- Put option with $110 exercise price and traded at $9

Straddle

- Straddle consists of a call and a put with the same exercise price and the same expiration date.
- Buyer of straddle buys the call and put, while the seller of a straddle sells the same two options.

Example

- Call and put both with $100 exercise prices. Call costs $5 and put trades for $4.

Strangle

- Strangle consists of a put and a call with the same expiration date and the same underlying asset.
- Call has an exercise price above the stock price and put has an exercise price below the stock price
- Buyer of strangle buys the call and put, while the seller of a straddle sells the same two options.

Example

- Call with an exercise price of $85 and a put with an exercise price of $80
- Call price is $3 and put price is $4

Butterfly Spread with Puts

- Butterfly spread uses three calls or three puts with the same expiration date on the same underlying stock
- Long trader buys one call with a low exercise price, buys one call with a high exercise price, and sells two calls with an intermediate exercise price.
- Long trader buys one put with a low exercise price, buys one put with a high exercise price, and sells two puts with an intermediate exercise price.

Exercise

- Long 1 call option: X = $105, $3 premium
- Short 2 call options: X = $100, $4 premium
- Long 1 call option: X = $95, $7 premium

Condor with Calls

- Condor is a specialised position that involves four options on the same underlying good and with the same expiration date. Four options have different exercise prices.
- Long condor with call options, trader buys a call with the lowest exercise price, sells a call with a higher exercise, sells a call with an even higher exercise price, and buys a call with the highest exercise price.
- Long condor with put options, trader buys a put with the lowest exercise price, sells a put wit a higher exercise price, sells a put with even higher exercise price, and buys a put with the highest exercise price.

Exercise

- Long call option: X = $90, $10 premium
- Short call option: X = $95, $7 premium
- Short call option: X = $100, $4 premium
- Long call option: X = $105, $2 premium

Exercise

- Long put option: X = $90, $2 premium
- Short put option: X = $95, $5 premium
- Short put option: X = $100, $9 premium
- Long put option: X = $105, $13 premium

Ratio Spreads

- Spread transaction in which two or more related options are traded in a specified proportion.
- A trader, for example, might buy a call with a lower exercise price and sell three calls with a higher exercise price. As the ratio of one instrument to the other can be varied without limit, there are infinitely many different ratio spreads that are possible.

Exercise

- Long two call options: X = $95, $7 premium
- Short one call option: X = $105, $3 premium
  (Trader utilised a 2:1 ratio from bull spread)

Protective Put

Portfolio Insurance

- Stock investment with hedging position
- Long stock and long put option

Example: Protective Put

- Long stock at $100 cost
- Long put option with strike price of $95, $3 premium

Covered Call

Stock investment with option writing

- Long stock and short call option

Example

- Long stock at $100 cost
- Short call option with strike price of $100, $3 premium

Principles of Options Pricing

Intrinsic value

- Minimum price of the option
- Proceed from option if exercise

CALL OPTION:

PUT OPTION:

Intrinsic value: profit that could be made if the option was immediately exercised
Time value: the difference between the option price and the intrinsic value

Option Premium	=	Intrinsic Value	+	Time Value

Black-Scholes Model

$$c = S_0 N(d_1) - Xe^{-rT} N(d_2)$$

$$p = Xe^{-rT}\ N(-d_2) - S_0 N(-d_1)$$

$$\text{where}\quad d_1 = \frac{\ln(\frac{S_0}{X}) + (r + \frac{\sigma^2}{2})T}{\sigma\sqrt{T}}$$

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

c	European call option price	K	Strike price
p	European put option price	S_0	Spot asset price today
T	Life of option	σ	Volatility of the spot asset price
r	Risk-free rate	N( )	Normal distribution

Assumptions in Black-Scholes Model

- Fischer Black and Myron Scholes developed their option pricing model under the assumptions that asset prices adjust to prevent arbitrage, that stock prices change continuously, and that stock returns follow a log-normal distribution.
- Black-Scholes model holds for European call options on **stocks** with **no dividends**.

- Also, assume that the interest rate and volatility of the stock remain constant over the life of the option.
- Black-Scholes derived mathematically through stochastic calculus.

Put-Call Parity

$$c + \frac{X}{e^{rT}} = p + S_0$$

For European options, a long call combined with a short put can mimic the profit and loss pattern at expiration date for the underlying stock. By adding an investment in the risk-free bond, we can create a portfolio that synthesises the stock.

Adjustments for Known Dividends

- Subtract the present value of the dividend from the current stock price before applying Black-Scholes Model.
- Stock price should be adjusted by subtracting the present value of all dividends that are expected to occur before the expiration date of the option. Dividends expected after the option expires can be ignored, because the option will already have been exercised.

Example

Consider call and put options with a common exercise price of $100 and 150 days until expiration. Assume that the underlying stock trades for $102, risk free rate is 9.00 percent per year and the standard deviation for the stock is 30.00 percent per year.

Using Black-Scholes Model or Merton Model, where appropriated,
Compute call option and put option prices
(1) no dividend during options' lives
(2) pay dividend $3 in 90 days