Options Part 4

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Calculating PNL (1 of 8)

- Suppose you trade an option $\mathcal{O}$ at a price P on trade-date T_1.
- Suppose you hold the option until expiration, which is trade-date T_n.
- The letter i will serve as an index over the trade-dates, so $i = 1, \ldots, n$.

Calculating PNL (2 of 8)

- Let B_i and A_i be the end-of-day bid/ask prices of the option for trade-date T_i.
- Note that $B_n = A_n =$ option-payoff.
- D_i - daily PNL for the trade as of end-of-day T_i.
- C_i - trade-to-date (cummulative) PNL for the trade as of end-of-day T_i.
- **Intuition:** The cummulative PNL on a trade is how much money you make if you unwind the trade at current market values.

Calculating PNL (3 of 8)

Cummulative as Sum of Daily: **BUY**

$$D_i = \begin{cases} B_1 - P & i = 1 \\ B_i - B_{i-1} & i > 1 \end{cases}$$

$$C_i = \sum_{k=1}^{i} D_k$$

Exercise: Show that $C_j = B_j - P$.

Calculating PNL (4 of 8)

Cummulative as Sum of Daily: **SELL**

$$D_i = \begin{cases} P - A_1 & i = 1 \\ A_{i-1} - A_i & i > 1 \end{cases}$$

$$C_i = \sum_{k=1}^{i} D_k$$

Exercise: Show that $C_i = P - A_i$.

Calculating PNL (5 of 8)

Daily as Change in Cummulative: **BUY**

$$C_i = B_i - P$$

$$D_i = \begin{cases} C_1 & i = 1 \\ C_i - C_{i-1} & i > 1 \end{cases}$$

Exercise: Show that both formulations of D_i are equivalent.

Calculating PNL (6 of 8)

Daily as Change in Cummulative: **SELL**

$$C_i = P - A_i$$

$$D_i = \begin{cases} C_1 & i = 1 \\ C_i - C_{i-1} & i > 1 \end{cases}$$

Exercise: Show that both formulations of D_i are equivalent.

Calculating PNL (7 of 8)

- Suppose on 9/16/2013 we buy the 169 SPY expiring 9/21, paying EOD Ask.
- Here is the price data for that option until expiration:

```
## # A tibble: 5 x 3
##   trade_date   bid   ask
##   <date>     <dbl> <dbl>
## 1 2013-09-16 0.82   0.84
## 2 2013-09-17 0.580  0.59
## 3 2013-09-18 0.09   0.1
## 4 2013-09-19 0.05   0.06
## 5 2013-09-20 0      0
```

Calculating PNL (8 of 8)

Exercise: Verify the following PNL calculations.

```
## # A tibble: 5 x 5
##   trade_date   bid   ask     D_i   C_i
##   <date>     <dbl> <dbl>   <dbl> <dbl>
## 1 2013-09-16 0.82   0.84 -0.02   -0.02
## 2 2013-09-17 0.580  0.59 -0.24   -0.26
## 3 2013-09-18 0.09   0.1  -0.49   -0.75
## 4 2013-09-19 0.05   0.06 -0.0400 -0.79
## 5 2013-09-20 0      0    -0.05   -0.84
```

Black-Scholes-Merton Formula (1 of 1)

$$m = \text{BSM}(\text{p/c}, K, \text{T}, S_t, \sigma, \delta, r)$$

Contract Features

- p/c - put or call
- K - strike price
- T - expiration date (time to expiration)

Market Values

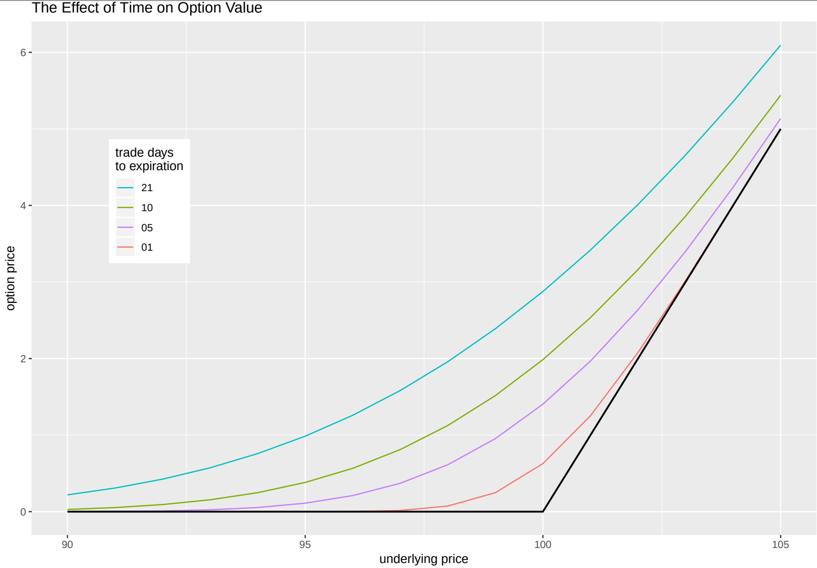
- S_t - current underlying price
- σ - estimate of the standard deviation log-return of the price of underlying between now and expiration
- δ - estimate of dividends paid over the life of the option
- r - risk-free interest rate

Black-Scholes-Merton Formula (2 of 2)

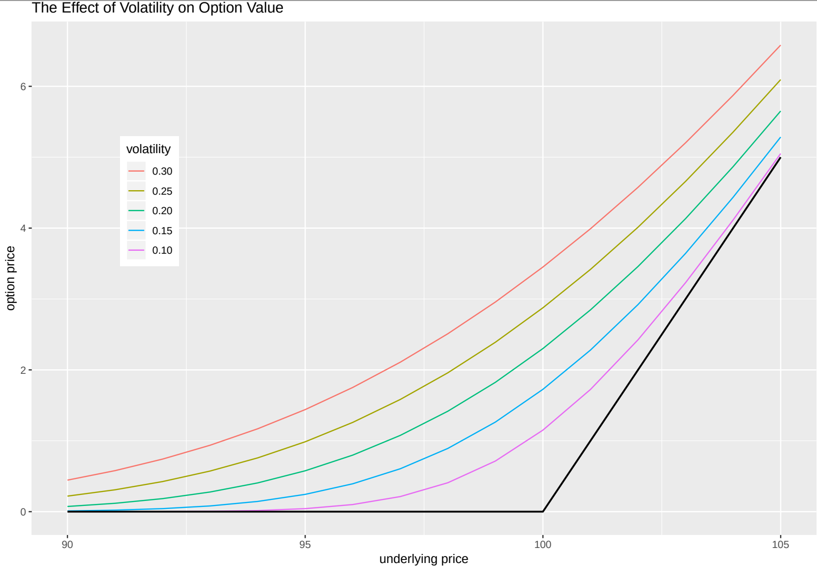
- For this class, we won't need to examine the BSM formula too closely, or write a BSM function from scratch.
- A more important skill wil be to use pre-existing BSM functions (and implied volatility functions) in analysis code.
- I usually use the `fOptions` package.
- **Exercise:** Install the `fOptions` package and quickly read through pp 22-27 of its documentation PDF.

Greeks Preview (1 of 4)

Greeks Preview (2 of 4)



Greeks Preview (3 of 4)



Greeks Preview (4 of 4)

Some Facts

1. Optionality - as evidenced by vega, theta, gamma - is greatest when options are ATM.

2. Theta is Negative: an option loses value as it nears expiration.

3. Vega is Positive: the more volatile the underlying, the more valuable the option.

4. Regarding Delta:
   - Approximiately 0.50 when option is ATM.
   - Approaches 0.00 as option gets farther out of the money.
   - Approaches 1.00 as option goes farther in the money.
   - *VERY roughly* the probability that the option expires ITM.
   - Used to refer to the moniness of an option.