

Options

Objective: The purpose of this assignment is to introduce you to options using the Black-Scholes option pricing model.

Company: Amazon.com, Inc., (<http://www.amazon.com>) is an online retailer of books, music, DVD/video, toys, electronics, software, and home products. Currently, Amazon has over 17 million customer accounts in over 150 countries. Since its initial public offering, Amazon has never made a profit although their revenues keep increasing. Bezos, the company's founder has remained noncommittal as to when the company might turn a profit. Recently (Oct. 24, 2000) Amazon reported better-than-expected third-quarter results, including lower operating losses, thanks to operational improvements, increased customer accounts and rising sales of consumer electronics. This piece of good news is in stark contrast to continuing problems at the firm. In the past quarter, (July 25, 2000) Joseph Galli Jr. resigned as President and Jeff Bezos, founder, chairman and Chief Executive Officer assumed his duties. In addition to this, the Securities & Exchange Commission is currently inquiring about Amazon's accounting of revenues from partners that use Amazon's Web site to sell products or market themselves. Furthermore, Lehman Brothers' debt analyst Ravi Suria in a June research report predicted that Amazon.com could run into a money crunch in early 2001 unless it drastically reduces its cash-burn rate.



Jeff Bezos

Assignment: Download the Amazon data and use the spreadsheet to answer the following questions.

1. (5 points) Graph the call price (Y-axis) against the strike price (X-axis) using a line graph. What is the relationship between the call price and the strike price for a given stock price?
2. (35 points) Calculate the implied volatility for each of the 22 call options in the downloaded spreadsheet using the Black-Scholes option pricing model (BSOPM). To calculate the implied volatility you will need to use the SOLVER option under the TOOLS submenu. Also, to calculate
 - The normal cumulative distribution e.g., $N(d_1)$ and $N(d_2)$, use the =NORMSDIST() worksheet function in Excel.
 - The remaining time to maturity in years, assume that a year has 250 business days. The number of business days from November 9th to December 15th is 27.

(Hint: In using Solver, Set the Target Cell: to the cell which contains the call option formula, choose the Value of: option in the Equal to: row and type in the value of the

current call price, set By Changing Cells: to the cell that contains your guess for the variance (or standard deviation). Discuss whether the implied volatility is constant for various strike prices. Is the implied volatility higher or lower for in-the-money call options relative to out-of-the-money call options?

3. (5 points) Graph the implied volatilities. The y-axis of your graph is the implied standard deviation of the various call options. The x-axis is the strike/exercise price. Is the implied standard deviation constant over the range of exercise prices or does it resemble a "smile"☺?

4. (10 points) An alternative method to obtain the implied volatility is to calculate the stock price volatility from stock prices. First calculate the log of the price relatives $r_T = \ln[P_T/P_{T-1}]$. Next, calculate the standard deviation of the log of the price relatives. Finally, annualize this standard deviation by using the formula $\sigma^*(\text{number of periods per year}^{0.5}) = \sigma^*\sqrt{\text{number of periods per year}}$. If the data are monthly prices, this term will be $\sqrt{12}$; if the data are weekly prices, then this term will be $\sqrt{52}$. For daily data, it's common to use $\sqrt{250}$. (See Appendix A of this handout for an example of calculating the implicit volatility using monthly prices) Calculate the average implied volatility using the *weekly* stock prices given in your spreadsheet.

5. (10 points) Calculate the theoretical call price for the Amazon call option with a strike price of 35. Also, calculate the theoretical put price for an Amazon put option with a strike price of 35 and the same maturity as that of the call option. In doing your calculations, use the average of the implied volatility for all call options *except* the call option being price. Redo your calculations using the implied volatility that you obtained in question 4.

Put-Call Parity: Recall that a put with the same strike price X and same maturity date T on the same stock has a put price P of $P = C - S + Xe^{-rT}$. Substituting for C in the Black-Scholes formula yields

$$P = Xe^{-rT}N(-d_2) - SN(-d_1)$$

6. (30 points) Amazon, like other Internet companies, gives its executives a fairly sizeable portion of their compensation in the form of executive stock options.¹ Based on Amazon's stock price on November 9, 2000 of \$31.25 per share, how much is each executive worth in terms of stock options granted in fiscal year 1999? Information on executive options is located in the AMZN Executive Options worksheet of the downloaded spreadsheet and was obtained from the most recent proxy statement using the Global Access online database (http://www.nyu.edu/library/bobst/database/d_bus.htm). In doing your calculations, use the following assumptions:

- Volatility (σ): Use the average of the implied volatilities that you calculated in question 2.

¹For a practical overview of executive stock options, visit <http://www.money.com/money/101/> and select 10. Employee stock options.

- Riskfree rate (r_F): Use the risk free rate corresponding to the appropriate maturity. For example, if you are trying to price an option with a 5 year maturity, you would use the rate on a 5 year Treasury bond.
- Number of options: Is the Number of securities underlying options granted divided by 100. We assume that each option gives the holder the right to purchase 100 shares of stock.
- Maturity (T): The option granted to Mr. Dalzell has a term of 10 years, the option granted to Mr. Galli has a term of 20 years and 3 months, the option granted to Mr. Jenson has a term of 20 years and 3 months, and the option granted to Mr. Wilke has a term of 15 years and 3 months.

On September 2, 1999 Amazon's stock had a 2-for-1 stock split. The stock split only affects Mr. Dalzell and Mr. Galli's stock options since they were granted prior to the split. (Note: When a stock splits, call and put options are adjusted accordingly. If a stock splits 3 for 1 you get three times as many options for one-third the strike price)

7. (5 points) Redo the preceding question (#6) using the implied volatility that you calculated in question 4.

Appendix A: Calculating the Implied Volatility Using Monthly Prices

We will demonstrate how to calculate the implied volatility using the monthly prices of Barnes and Noble.com (ticker: BNBK).

	A	B	C	D	E
1	Date	Mo. Price	$\ln(P_T/P_{T-1})$	σ	$\sigma*\sqrt{12}$
2	Oct-99	18.375			
3	Nov-99	19	0.033448	0.20903	0.724102
4	Dec-99	14.1875	-0.29208		
5	Jan-00	11.625	-0.1992		
6	Feb-00	8	-0.37372		
7	Mar-00	9.4375	0.16525		
8	Apr-00	10.9375	0.147506		
9	May-00	9.3125	-0.16084		
10	Jun-00	6.5312	-0.35477		
11	Jul-00	5.125	-0.24246		
12	Aug-00	4	-0.24784		
13	Sep-00	4.9062	0.204205		
14	Oct-00	3.9062	-0.22793		

In cell C3, $r_{\text{Nov-99}} = \ln(19/18.375) = .033448$

cell D3, $\sigma_{\text{Weekly}} = \text{stdev}(C3:C14) = .20903$

cell E3, $\sigma_{\text{Annual}} = .20903*\text{sqrt}(12) = .724102$