

Chapter 21

Valuing Options

Multiple Choice Questions

1. Relative to the underlying stock, a call option always has:

- A) A higher beta and a higher standard deviation of return
- B) A lower beta and a higher standard deviation of return
- C) A higher beta and a lower standard deviation of return
- D) A lower beta and a lower standard deviation of return

Answer: A Type: Difficult Page: 565

2. A call option has an exercise price of \$100. At the final exercise date, the stock price could be either \$50 or \$150. Which investment would combine to give the same payoff as the stock?

- A) Lend PV of \$50 and buy two calls
- B) Lend PV of \$50 and sell two calls
- C) Borrow \$50 and buy two calls
- D) Borrow \$50 and sell two calls

Answer: A Type: Difficult Page: 566

Response: Value of two calls: $2(150 - 100) = 100$ or value of two calls =: $2(0) = 0$ (not exercised);
payoff = $100 + 50 = 150$ or payoff = $0 + 50 = 50$

3. The option delta is calculated as the ratio:

- A) (the spread of possible share prices) / (the spread of possible option prices)
- B) (the share price) / (the option price)
- C) (the spread of possible option prices) / (the spread of possible share prices)
- D) (the option price) / (the share price)

Answer: C Type: Medium Page: 567

4. Suppose Ralph's stock price is currently \$50. In the next six months it will either fall to \$30 or rise to \$80. What is the option delta of a call option with an exercise price of \$50?

- A) 0.375
- B) 0.500
- C) 0.600
- D) 0.75

Answer: C Type: Medium Page: 567

Response: Option delta = $(30 - 0)/(80 - 30) = 30/50 = 0.6$

5. Suppose Waldo's stock price is currently \$50. In the next six months it will either fall to \$40 or rise to \$60. What is the current value of a six-month call option with an exercise price of \$50? The six-month risk-free interest rate is 2% (periodic rate).

- A) \$5.39
- B) \$15.00
- C) \$8.25
- D) \$8.09

Answer: A Type: Difficult Page: 567

Response:

Replicating portfolio method: Call option payoff = $60 - 50 = 10$ and zero;

$(60)(A) + (1.02)(B) = 10$, $(40)(A) + 1.02(B) = 0$; $A = 0.5$ (option delta) &

$B = -19.61$; call option price (current) = $0.5(50) - 19.61 = \$5.39$

Risk-neutral valuation: $50 = [x(60) + (1-x)40]/1.02$; $x = 0.55$; $(1-x) = 0.45$;

Call option value = $[(0.55)(10) + (0.45)(0)]/(1.02) = \5.39

6. Suppose Waldo's stock price is currently \$50. In the next six months it will either fall to \$40 or rise to \$80. What is the current value of a six-month call option with an exercise price of \$50? The six-month risk-free interest rate is 2% (periodic rate).

- A) \$2.40
- B) \$15.00
- C) \$8.25
- D) \$8.09

Answer: D Type: Difficult Page: 567

Response:

Replicating portfolio method: Call option payoff = $80 - 50 = 30$ and zero;

$(80)(A) + (1.02)(B) = 30$, $(40)(A) + 1.02(B) = 0$; $A = 0.75$ (option delta) &

$B = -29.41$; call option price (current) = $0.75(50) - 29.41 = \$8.09$

Risk-neutral valuation: $50 = [x(80) + (1-x)40]/1.02$; $x = 0.275$; $(1-x) = 0.725$;

Call option value = $[(0.275)(30) + (0.725)(0)]/(1.02) = \8.09

7. Suppose Ann's stock price is currently \$25. In the next six months it will either fall to \$15 or rise to \$40. What is the current value of a six-month call option with an exercise price of \$20? The six-month risk-free interest rate is 5% (periodic rate). [Use the risk-neutral valuation method]

- A) \$20.00
- B) \$8.57
- C) \$9.52
- D) \$13.10

Answer: B Type: Difficult Page: 567

Response: Method I: $25 = [x(40) + (1-x)15]/1.05$; $x = 0.45$ $1-x = 0.55$

Call option price = $[(0.45)(20) + (0.55)(0)]/(1.05) = \8.57

8. Suppose Ann's stock price is currently \$25. In the next six months it will either fall to \$15 or rise to \$40. What is the current value of a six-month call option with an exercise price of \$20? The six-month risk-free interest rate is 5% (periodic rate). [Use the replicating portfolio method]

- A) \$20.00
- B) \$8.57
- C) \$9.52
- D) \$13.10

Answer: B Type: Difficult Page: 567

Response: $40(A) + 1.05(B) = 20$; $15(A) + 1.05(B) = 0$; $A = 0.8$; $B = -11.43$

Call option price = $25(0.8) - 11.43 = \$8.57$

9. Suppose Carol's stock price is currently \$20. In the next six months it will either fall to \$10 or rise to \$40. What is the current value of a six-month call option with an exercise price of \$12? The six-month risk-free interest rate (periodic rate) is 5%. [Use the risk-neutral valuation method]

- A) \$9.78
- B) \$10.28
- C) \$16.88
- D) \$13.33

Answer: A Type: Difficult Page: 567

Response: $20 = [x(40) + (1-x)(10)] / 1.05$; $x = 0.367$; $(1-x) = 0.633$

Call option price = $[(0.367)(28) + (0.633)(0)] / (1.05) = \9.78

10. Suppose Carol's stock price is currently \$20. In the next six months it will either fall to \$10 or rise to \$40. What is the current value of a six-month call option with an exercise price of \$12? The six-month risk-free interest rate (periodic rate) is 5%. [Use the replicating portfolio method]

- A) \$9.78
- B) \$10.28
- C) \$16.88
- D) \$13.33

Answer: A Type: Difficult Page: 567

Response: $40(A) + 1.05(B) = 28$; $10(A) + 1.05(B) = 0$; $A = 0.9333$; $B = -8.89$

Call option price = $(0.9333)(25) - 8.89 = 9.78$

11. Suppose Victoria's stock price is currently \$20. In the next six months it will either fall to \$10 or rise to \$30. What is the current value of a put option with an exercise price of \$12? The six-month risk-free interest rate is 5% (periodic rate).

- A) \$9.78
- B) \$2.00
- C) \$0.86
- D) \$9.43

Answer: C Type: Difficult Page: 568

Response:

Replicating portfolio method: $30(A) + 1.05(B) = 0$; & $10(A) + 1.05(B) = 2$;

$A = -0.1$ (option delta) & $B = 2.86$; Put option price = $-(0.1)(20) + 2.86 = 0.86$;

Risk-neutral valuation: $20 = [x(30) + (1-x)(10)] / 1.05$; $x = 0.55$ and $(1-x) = 0.45$

Put option price = $[(0.55)(0) + (0.45)(2)] / (1.05) = 0.86$

12. The delta of a put option is always equal to:
- A) The delta of an equivalent call option
 - B) The delta of an equivalent call option with a negative sign
 - C) The delta of an equivalent call option minus one
 - D) None of the above

Answer: C Type: Difficult Page: 569

13. If the delta of a call option is 0.6, calculate the delta of an equivalent put option
- A) 0.6
 - B) 0.4
 - C) -0.4
 - D) -0.6

Answer: C Type: Difficult Page: 569

Response: $0.6 - 1 = -0.4$

14. Suppose Victoria's stock price is currently \$20. Six-month call option on the stock with an exercise price of \$12 has a value of \$9.43. Calculate the price of an equivalent put option if the six-month risk-free interest rate is 5% (periodic rate).

- A) \$0.86
- B) \$9.43
- C) \$8.00
- D) \$12.00

Answer: A Type: Difficult Page: 570

Response: $\text{Value of Put} = 9.43 - 20 + 12/(1.05) = \0.8

15. If e is the base of natural logarithms, and (σ) is the standard deviation of the continuously compounded annual returns on the asset, and h is the interval as a fraction of a year, then the quantity $(1 + \text{upside change})$ is equal to:

- A) $e^{[(\sigma)^2 \cdot \text{SQRT}(h)]}$
- B) $e^{[h \cdot \text{SQRT}(\sigma)]}$
- C) $(\sigma)^2 e^{[\text{SQRT}(h)]}$
- D) none of the above.

Answer: A Type: Difficult Page: 574

16. If u equals the quantity $(1 + \text{upside change})$, then the quantity $(1 + \text{downside change})$ is equal to:

- A) $-u$
- B) $-1/u$
- C) $1/u$
- D) none of the above.

Answer: C Type: Medium Page: 574

17. If the standard deviation of the continuously compounded annual returns (σ) on the asset is 40%, and the time interval is a year, then the upside change is equal to:

- A) 88.2%
- B) 8.7%
- C) 63.2%
- D) 49.18%

Answer: D Type: Difficult Page: 574

Response: $(1 + u) = e^{(0.4)} = 1.4918$ or upside change = 49.18%

18. If the standard deviation for continuously compounded annual returns on the asset is 40% and the interval is a year, then the downside change is equal to:

- A) 27.4%
- B) 53.6%
- C) 32.97%
- D) 38.7%

Answer: C Type: Difficult Page: 574

Response:

$(1 + u) = e^{[(0.4 \times 1)]} = 1.4182$; downside change = $1/1.4182 = 1 + d = 0.67032$

$d = -0.3297$; down % = 32.97%

19. If the standard deviation of continuously compounded annual returns on the asset is 20% and the interval is half a year, then the downside change is equal to:

- A) 37.9%
- B) 19.3%
- C) 20.1%
- D) 13.2%

Answer: D Type: Difficult Page: 574

Response: $(1 + u) = e^{[(0.2) \times 0.5]} = 1.152$ or $d = 1/1.152 = .868$ or downside change = 13.2%

20. If the standard deviation of continuously compounded annual returns on the asset is 40% and the interval is a year, then the downside change is equal to :

- A) 27.4%
- B) 53.6%
- C) 33.0%
- D) 38.7%

Answer: C Type: Difficult Page: 574

Response: $(1 + u) = e^{(0.4)} = 1.492$ or $(1 + d) = 1/1.492 = 0.67$ or downside change = 33%

21. A stock is currently selling for \$50. The stock price could go up by 10% or fall by 5% each month. The monthly interest rate is 1% (periodic rate). Calculate the price of a European call option on the stock with an exercise price of \$50 and a maturity of two months. (use the two-stage binomial method)

- A) \$5.10
- B) \$2.71
- C) \$4.78
- D) \$3.62

Answer: B Type: Difficult Page: 574

Response: $50 = [55(x) + 47.5(1-x)]/(1.01)$; $x = 0.4$; $1-x = 0.6$

Payoffs at the end of month-2: \$10.5; \$2.25; and zero; [Exercise price = \$50]

End of one month values: $[(10.5)(0.4) + 2.25(0.6)]/1.01 = 5.495$ and $[2.25(0.4) + 0]/1.01 = 0.891$

Price of the call option = $[5.495(0.4) + (0.891)(0.6)]/1.01 = 2.71$

22. An European call option with an exercise price of \$50 has a maturity (expiration) of six months, stock price of \$54 and the instantaneous variance of the stock returns 0.64. The risk-free rate is 9.2%. Calculate the value of d_2 (approximately).

- A) +0.0656
- B) -0.0656
- C) +0.5656
- D) -0.5656

Answer: B Type: Medium Page: 576

Response: $d_2 = 0.5 - 0.8(0.5^{0.5}) = -0.0656$

23. An European call option with an exercise price of \$50 has a maturity (expiration) of six months, stock price of \$54 and the instantaneous variance of the stock returns 0.64. The risk-free rate is 9.2%. Then $[d_1]$ has a value of (approximately):

- A) 0.3
- B) 0.7
- C) -0.7
- D) 0.5

Answer: D Type: Difficult Page: 576

Response: $d_1 = [\ln(54/50) + (0.092 + (0.64/2))(0.5)]/[(0.8)(0.7071)] = 0.5$

24. Cola Company has call options on its common stock traded in the market. The options have an exercise price of \$45 and expire in 156 days. The current price of the Cola stock is \$44.375. The risk-free rate is 7% per year and the standard deviation of the stock returns is 0.31. The value of $[d_1]$ is (approximately):

- A) 0.0226
- B) 0.18
- C) -0.3157
- D) 0.3157

Answer: B Type: Difficult Page: 576

Response: $d_1 = [\ln(44.375/45) + [0.07 + (0.096/2)]] [165/365] / [(0.31)(0.6538)] = 0.18$

25. Cola Company has call options on its common stock traded in the market. The options have an exercise price of \$45 and expire in 156 days. The current price of the Cola stock is \$44.375. The risk-free rate is 7% per year and the standard deviation of the stock returns is 0.31. Calculate the value of d_2 : (approximately)

- A) +0.0227
- B) -0.0227
- C) +0.2027
- D) -0.2027

Answer: B Type: Medium Page: 576

Response: $d_2 = d_1 - [(\sigma)(\text{SQRT}(t))]$; $d_2 = 0.18 - (0.31)[(156/365)^{0.5}] = -0.0227$

26. If the value of d_1 is 1.25, then the value of $N(d_1)$ is equal to:

- A) -0.1056
- B) 1.25
- C) 0.25
- D) 0.844

Answer: D Type: Medium Page: 578

Response: Use the Cumulative Probabilities of the Standard Normal Distribution Table

27. If the value of d_2 is -0.5, then the value of $N(d_2)$ is:

- A) -0.1915
- B) 0.6915
- C) 0.3085
- D) 0.8085

Answer: C Type: Medium Page: 578

Response: Use the Cumulative Probabilities of the Standard Normal Distribution Table

28. If the value of d is -0.75, calculate the value of $N(d)$:

- A) 0.2266
- B) -0.2266
- C) 0.7734
- D) -0.2734

Answer: A Type: Medium Page: 578

29. If the strike price increases then the: [Assume everything else remaining the same]

- A) Value of the put option increases and that of the call option decreases
- B) Value of the put option decreases and that of the call option increases
- C) Value of both the put option and the call option increases
- D) Value of both the put option and the call option decreases
- E) None of the above

Answer: A Type: Medium Page: 578

30. If the volatility (variance) of the underlying stock increases then the: [Assume everything else remaining the same]

- A) Value of the put option increases and that of the call option decreases
- B) Value of the put option decreases and that of the call option increases
- C) Value of both the put option and the call option increases
- D) Value of both the put option and the call option decreases
- E) None of the above

Answer: C Type: Medium Page: 578

31. The Black-Scholes OPM is dependent on which five parameters?

- A) Stock price, exercise price, risk free rate, beta, and time to maturity
- B) Stock price, risk free rate, beta, time to maturity, and variance
- C) Stock price, risk free rate, probability, variance and exercise price
- D) Stock price, exercise price, risk free rate, variance and time to maturity

Answer: D Type: Difficult Page: 578

32. The value of $N(d)$ in the Black-Scholes model can take any value between:

- A) -1 and $+1$
- B) 0 and $+1$
- C) -1 and 0
- D) None of the above

Answer: B Type: Medium Page: 578

33. $N(d_1)$ in the Black-Scholes model represents

- (I) call option delta
 - (II) hedge ratio
 - (III) probability
- A) I only
 - B) II only
 - C) III only
 - D) I, II, and III

Answer: D Type: Medium Page: 578

34. The term $[N(d_2) \cdot PV(EX)]$ in the Black-Scholes model represents:

- A) call option delta
- B) bank loan
- C) put option delta
- D) none of the above

Answer: B Type: Medium Page: 578

35. Which of the following statements regarding American puts is/are true?

- A) An American put can be exercised any time before expiration
- B) An American put is always more valuable than an equivalent European put
- C) Multi-period binomial model can be used to value an American put
- D) All of the above

Answer: D Type: Medium Page: 582

36. A stock is currently selling for \$50. The stock price could go up by 10% or fall by 5% each month. The monthly interest rate is 1% (periodic rate). Calculate the price of an American put option on the stock with an exercise price of \$55 and a maturity of two months. (Use the two-stage binomial method)

- A) \$5.10
- B) \$3.96
- C) \$4.78
- D) None of the above

Answer: A Type: Difficult Page: 582

Response: $p = 1 - (-5)/(10 - (-5)) = 0.40$ $1 - p = 0.6$

End of one month values: $[(0)(0.4) + (2.75)(0.6)]/1.01 = 1.6337$ or zero

And $[(2.75)(0.4) + (9.875)(0.6)]/1.01 = \6.9555 or \$7.5 if exercised;

$P = [0.4(1.6337) + (7.5)(0.6)]/1.01 = \5.10

37. Suppose the exchange rate between US dollars and British pound is US\$1.50 = BP1.00. If the interest rate is 6% per year what is the adjusted price of the British pound when valuing a foreign currency option with an expiration of one year? (Approximately)

- A) \$1.905
- B) \$1.4151
- C) \$0.7067
- D) None of the above

Answer: B Type: Difficult Page: 583

Response: Adjusted price = $1.5/1.06 = 1.4151$

38. If the interest rate is 10%, the upside change is +25% and the downside change is -20%. Calculate the risk-neutral probability of upside change.

- A) 0.5
- B) 0.6667
- C) 0.75
- D) None of the above.

Answer: B Type: Difficult Page: 584

Response: $p = 10 - (-20)/(25 - (-20)) = 0.6667$

39. If the interest is 8%, the upside change is +40% and the downside change is -40% calculate the risk-neutral probability of upside change.

- A) 0.50
- B) 0.80
- C) 0.60
- D) None of the above.

Answer: C Type: Difficult Page: 584

Response: $p = \frac{8 - (-40)}{40 - (-40)} = 0.6$

40. If the interest rate is 12%, the upside change is 20% and the downside change is -10%, calculate the risk-neutral probability of upside change.

- A) 0.733
- B) 0.5
- C) 0.1
- D) None of the above.

Answer: A Type: Difficult Page: 584

Response: $p = \frac{12 - (-10)}{20 - (-10)} = 0.7333$

41. A stock is currently selling for \$100. One year from today the stock price could go up by 30% or go down by 20%. The risk-free interest rate is 10%[APR]. Calculate the price of a one-year European call option on the stock with an exercise price of \$100 using the binomial method.

- A) \$30.00
- B) \$16.36
- C) \$15.67
- D) None of the above.

Answer: B Type: Difficult Page: 584

Response: $p = \frac{10 - (-20)}{30 - (-20)} = 0.60$; $C = [(0.6)(30) - (0.4)(0)]/1.1 = \16.36

42. A stock is currently selling for \$50. One month from today the stock price could go up by 10% or fall by 50%. If the monthly interest rate is 1% (periodic rate) calculate the price of a European call option on the stock with an exercise price of \$48 and a maturity of one month (use the binomial method).

- A) \$2.77
- B) \$2.00
- C) \$1.98
- D) None of the above.

Answer: A Type: Difficult Page: 584

Response: $p = \frac{1 - (-5)}{10 - (-5)} = 0.40$; $C = [(0.4)(7) + (0.6)(0)]/1.01 = \2.77

43. A stock is currently selling for \$50. The stock price could go up by 10% or fall by 5% each month. The monthly interest rate is 1% (periodic rate). Calculate the price of a European call option on the stock with an exercise price of \$48 and a maturity of two months. (use the two-stage binomial method)

- A) \$3.96
- B) \$2.77
- C) \$1.98
- D) None of the above.

Answer: A Type: Difficult Page: 584

Response: $p = 1 - (-5)/(10 - (-5)) = 0.40$ $1 - p = 0.6$

End of one month values: $[12.5(0.4) + (4.25)(.6)]/1.01 = 7.4752$

And $[(4.25)(.4) + (0.6)(0)]/1.01 = \1.6832 ; $C = [0.4(7.4752) + (0.6)(1.6832)]/1.01 = \3.96

44. A stock is currently selling for \$50. The stock price could go up by 10% or fall by 5% each month. The monthly interest rate is 1% (periodic rate). Calculate the price of a American put option on the stock with an exercise price of \$55 and a maturity of two months. (Use the two-stage binomial method)

- A) \$5.10
- B) \$3.96
- C) \$4.78
- D) None of the above.

Answer: A Type: Difficult Page: 584

Response: $p = 1 - (-5)/(10 - (-5)) = 0.40$ $1 - p = 0.6$

End of one month values: $[(0)(0.4) + (2.75)(.6)]/1.01 = 1.6337$ or zero

And $[(2.75)(.4) + (9.875)(0.6)]/1.01 = \6.9555 or \$7.5 if exercised;

$P = [0.4(1.6337) + (7.5)(0.6)]/1.01 = \5.10

45. A stock is currently selling for \$50. The stock price could go up by 10% or fall by 5% each month. The monthly interest rate is 1% (periodic rate). Calculate the price of a European put option on the stock with an exercise price of \$55 and a maturity of two months. (use the two-stage binomial method)

- A) \$5.10
- B) \$2.77
- C) \$4.78
- D) None of the above.

Answer: C Type: Difficult Page: 584

Response: $p = 1 - (-5)/(10 - (-5)) = 0.40$ $1 - p = 0.6$

End of one month values: $[(0)(0.4) + (2.75)(.6)]/1.01 = 1.6337$ or zero

And $[(2.75)(.4) + (9.875)(0.6)]/1.01 = \6.9555 or \$7.5 if exercised ;

$P = [0.4(1.6337) + (6.9555)(0.6)]/1.01 = \4.78

True/False Questions

T F 46. An option can be valued using the standard discounted cash flow procedure.

Answer: False Type: Medium Page: 565

T F 47. It is possible to replicate an investment in a call option by a levered investment in the underlying asset.

Answer: True Type: Medium Page: 566

T F 48. When risk-neutral probabilities are used, the cost of capital is the discount rate

Answer: False Type: Medium Page: 567

T F 49. Option delta for a put option is always positive

Answer: False Type: Difficult Page: 569

T F 50. For an European option: Value of put = Value of call) - share price + PV(exercise price)

Answer: True Type: Medium Page: 570

T F 51. The binomial model is a discrete time model

Answer: True Type: Medium Page: 570

T F 52. The Black-Scholes model is a discrete time model

Answer: False Type: Medium Page: 575

T F 53. $N(d_1)$ and $N(d_2)$ are probabilities and therefore take values between 0 and 1.

Answer: True Type: Medium Page: 578

T F 54. Multi-period binomial model can be used to evaluate an American put option

Answer: True Type: Medium Page: 582

Essay Questions

55. Briefly explain why discounted cash flow method (DCF) does not work for valuing options?

Type: Difficult Page: 565

Answer:

Discounted cash flow method has two steps. First, estimating cash flows; second, discounting these cash flows using an appropriate opportunity cost of capital. In case of options, the first part is quite difficult. But the second step is almost impossible as the risk of an option changes with changes in stock price. Also, the risk changes over time even without a change in the stock price.

56. Briefly explain why an option is always riskier than the underlying stock?

Type: Difficult Page: 566

Answer:

An investment in option can be replicated by borrowing a fraction of the cost of the stock at the risk-free rate and investing in the stock. Therefore, investing in an option is always riskier than investing only in the stock. The beta and the standard deviation of returns of an option is always higher than that of investing in the underlying stock

57. Briefly explain risk-neutral valuation in the context of option valuation.

Type: Difficult Page: 567

Answer:

The valuation method that uses risk-neutral probabilities to evaluate the current price of an option is known as risk-neutral valuation. The risk-neutral upside probability is calculated as:

$$p = [\text{risk-free rate} - \text{downside change}] / [\text{upside change} - \text{downside change}]$$

58. Briefly explain what is meant by risk-neutral probability?

Type: Difficult Page: 567

Answer:

Risk-neutral probability provides certainty equivalent expected payoffs. It assumes that the investor does not need a higher rate of return to invest in a risky asset. The present value of the payoffs are obtained by discounting at the risk-free rate of return.

59. Briefly explain the term "option delta."

Type: Medium Page: 567

Answer:

Option delta is the ratio of spread of possible option prices to spread of possible share prices. This is also the hedge ratio.

60. Give an example of an option equivalent investment using common stock and borrowing.

Type: Difficult Page: 567

Answer:

The current price of a stock is \$40. Stock price, one period from today, could be either \$50 or \$30. The exercise price is also \$40. The risk-free rate per period is 2%. The option payoff is \$10 in the up state and is zero in the down state. By borrowing \$14.74 today and buying 0.5 of a share of stock, one can replicate the payoffs from the option. The payoff in the upstate is, the value of the stock \$25 minus the payoff amount of the loan \$15, equal to \$10. The payoff in the downstate is, the value of the stock is \$15 minus the payoff amount of \$15, equal to zero. This is called a replicating portfolio.

61. Briefly explain put-call parity.

Type: Medium Page: 570

Answer:

The relationship between the value of an European option and the value of our equivalent put option is called put-call parity. If this does not hold, then investors have arbitrage opportunity.

62. Briefly explain how to choose the up and down values for the binomial method?

Type: Medium Page: 574

Answer:

$[1 + \text{upside change}] = e^{\sigma \sqrt{h}}$ and $[1 + \text{downside change}] = 1/[1 + \text{upside change}]$

Where: σ = standard deviation of the annual returns of the underlying stock. h = time to expiration expressed in years.