KCG

Advanced Options Training
高级期权培训

Presented to Dalian Commodity Exchange
December 12-13, 2013
2013年12月12-13号

Options期权

- Options are a contract between two parties in which one party (option buyer) retains the **right** to certain prescribed economic benefits.
- 期权是双方签订的一种合约，其中规定了一方（期权买方）有**权利**获得某种规定的经济利益
- The other party in the contract (option writer or option seller) has the **obligation** to meet the terms of the contract should the buyer choose to exercise the option.
- 当买方行权时，合约另一方（期权发行方或卖方）有**义务**履行合约条款
- The key words are **right** and **obligation** which is why the option buyer always pays a **premium** and the option writer always receives a premium.
- 关键词为**权利**和**义务**，这正是期权买方总是支付**权利金**，期权卖方收取**权利金**的原因

Calls and puts看涨和看跌期权

- Typically the option contract relates to the option to buy or sell an underlying asset at a specific price according to a known time table.
- 通常，期权合约主要规定权利所有者（期权买方）有权在规定时间以规定价格买入或卖出合约标的资产

  - The right to buy the underlying asset is a **call** option
  - 买入标的资产的权利为看涨期权
  - The right to sell the underlying asset is a **put** option
  - 卖出标的资产的权利为看跌期权
  - The asset whose price is the subject of the contract is known as the underlying asset or the underlier
  - 合同的标的物资产被称为“标的资产”
- The price specified in the contract is known as the **strike** price and the date on/by which the buyer must make her intentions known is referred to as the **expiration** date
- 合约规定的价格被称为“行权价”，期权买方必须决定是否行权的日期（或在此之前）被称为**到期日**。

Options
期权

- There are limitless ways in which options can be structured:
- 期权合约的设计方式有很多种：

  - Options with one, several or continuous expirations
  - 具有一个、多个或连续到期日期的期权
  - Options where the underlying asset changes its quantity or type of asset
  - 标的资产数量或类型可以发生变化的期权
  - Options where the strike can change or even be set after the fact
  - 行权价格可以变化，甚至可以根据实际情况设定的期权
  - And many other variations on these themes
  - 以及基于以上参数组合形成的多种其他期权

- Exchange traded options are typically structured around a known and fixed underlying asset, a fixed and known strike and a known expiration.
- 交易所上市期权通常设计为固定标的资产，固定行权价格以及固定到期日
- They are typically either European (exercise at expiration) or American (exercise anytime until expiration)
- 交易所上市期权通常分为欧式（到期日当日行权）或美式（到期日之前任何时间都可行权）

OTC options场外交易期权

- Over the counter (OTC) options can be far more complex (exotic) than ordinary options (vanilla)
- 场外交易期权比普通期权更为复杂（特殊）
- Examples include:
- 示例：
  - Exotic exercise: Bermudan, Canary
  - 特殊的行权：Bermudan期权、Canary期权
  - Exotic underlier: compound, double option, LEPO, exchange, basket, rainbow
  - 特殊的标的：组合期权、双向期权、低行权价格期权（LEPO）、交换期权、篮子期权、彩虹期权
  - Exotic denomination: cross, quanto
  - 特殊的计价方式：交叉期权、固定汇率期权
  - Exotic path dependence: look back, Asian, Russian, Israeli, Parisian, barrier, double barrier, binary, chooser, forward start, cliquet, etc.
  - 特殊的路径依赖性：回望期权、亚洲期权、俄罗斯期权、以色列期权、波斯期权、界限期权、双界限期权、二元期权、后定期权、远期定价期权、轮期期权

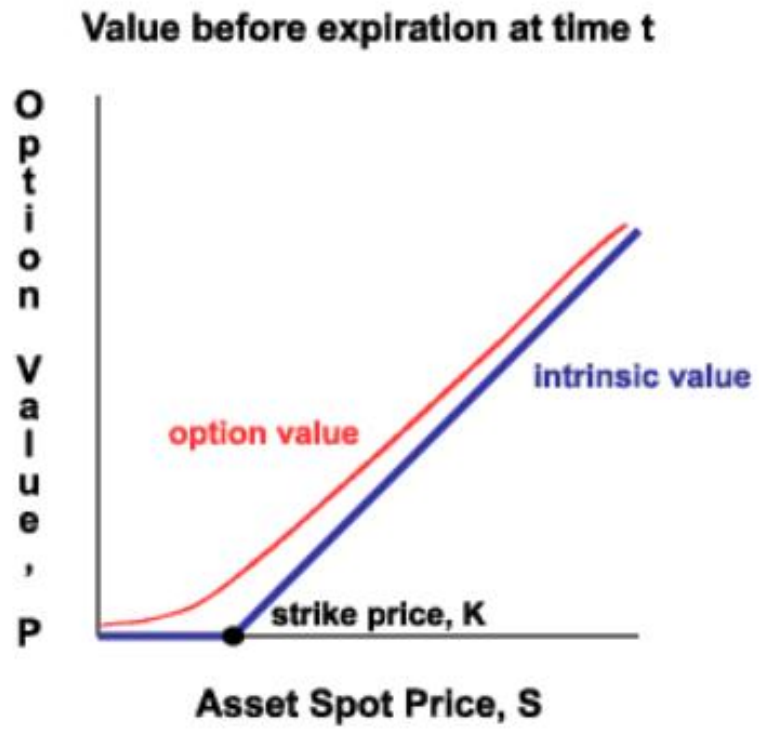
History of options期权历史

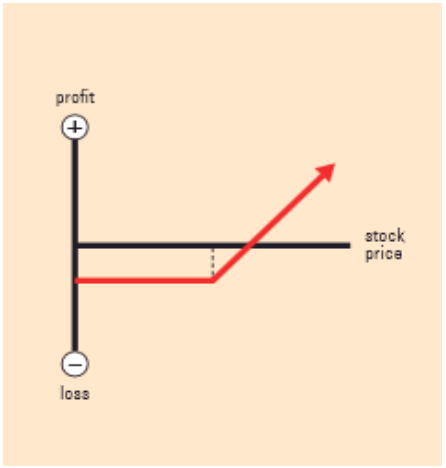
- In their more general contingent claims context, options have existed for a long time
- 期权具有很长的历史
  - Thales had a contingent claim on olive presses prior to 332 B.C.
  - 公元前332年，Thales在橄榄收获之前就购买了橄榄购买权
  - Tulip mania of 1636 spawned options trading
  - 1636年，郁金香价格飙升，引发大量期权交易
  - Options were traded in London during the 18th century. In mid 18th century options were declared illegal and they remained so for nearly 100 years.
  - 十八世纪，期权在伦敦交易。十八世纪中叶，期权交易被定性为非法，在此后的近一百年里都禁止期权交易
  - Russell Sage began trading OTC options in NY in 1872
  - 1872年，Russell Sage将OTC期权交易引入纽约
- Modern financial options trading began on April 26, 1973 when Chicago Board of Trade (CBOT) launched the Chicago Board of Options Exchange (CBOE). Also Options Clearing Corporation (OCC) was formed to clear trades.
- 1973年4月26日，CBOT成立了芝加哥期权交易所（CBOE)，开始交易现代金融期权。同时，成立期权清算公司用以交易清算。
  - Initially only call options were available, but by 1977 put options were introduced
  - 最初，只能交易看涨期权，但在1977年开始，也能交易看跌期权了
  - On the first day of trading 911 contracts were traded on 16 stocks
  - 第一个交易日当天，16支股票的期权共计产生911手交易量

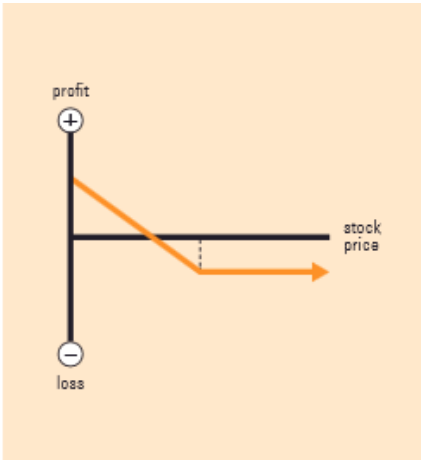
Intrinsic and time value内涵和时间价值

- intrinsic value of in-the-money options equals the payoff that could be obtained from the immediate exercise of the option
- 实值期权的内涵价值=即刻行权获得的收益
  - for a call option: stock price – exercise price
  - 看涨期权内涵价值=股价-行权价
  - for a put option: exercise price – stock price
  - 看跌期权内内涵价值=行权价-股价
  - the intrinsic value for out-the-money or at-the-money options is equal to 0
  - 平值期权和虚值期权的内涵价值=0
- time value of an option = difference between actual call price and intrinsic value
- 期权时间价值=实际看涨期权价格-内涵价值
  - as time approaches expiration date, time value goes to zero
  - 随着到期日期不断临近，时间价值最终会趋于零

Time value, intrinsic value, pay off function
时间价值、内涵价值、收益函数







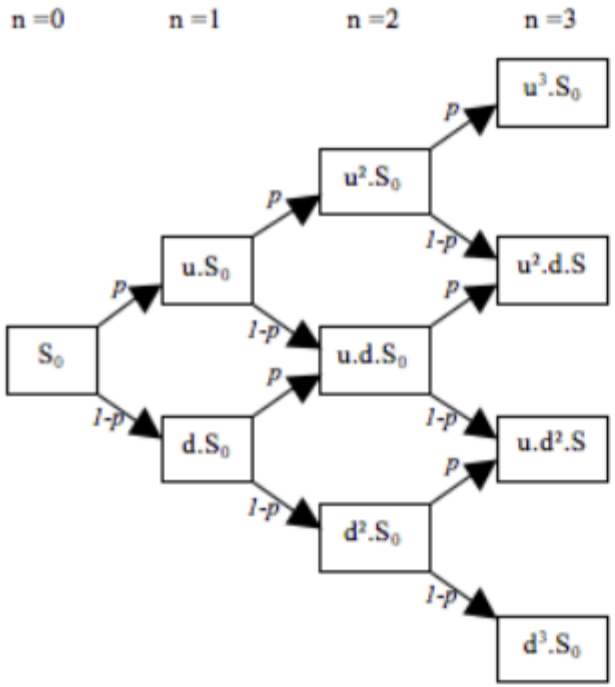
Option valuation (Black-Scholes formulation)
期权定价（布莱克-斯科尔斯期权定价公式）

- Markets are assumed to be liquid, have price-continuity, be fair and provide all players with equal access to available information. Efficient market hypothesis with zero transaction costs.
- 假设：市场具有足够流动性，价格具有持续性、公平性，所有交易者都能获得相同的信息，市场有效、交易成本为零
- Underlying security satisfies continuous price movements and that short selling with full use of proceeds is always available.
- 假设：标的证券的价格持续变动，且可以充分利用收益做空
- Constant risk-free interest rates are assumed to be the same for all and available to all.
- 假设：对所有交易者而言，利率都是一样的、固定的、无风险的
- The “no arbitrage” condition is assumed to hold at all times.
- 假设：“无套利”条件始终成立
- The price of the underlying security is assumed to follow a geometric Brownian process (random walk).、
- 那么，标的证券的价格应该符合以下几何布朗运动（随机运动）

$$\frac{dS}{S} = \mu dt + \sigma dX$$

$$\frac{\partial V}{\partial t} + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 V}{\partial S^2} + rS\frac{\partial V}{\partial S} - rV = 0.$$

Option valuation (price tree construct)
期权定价（价格树概念）



$$p = \frac{e^{rt/n} - d}{u - d}$$

$$u = e^{\sigma\sqrt{t/n}}$$

$$d = e^{-\sigma\sqrt{t/n}}$$

示例: Cox, Ross & Rubenstein (CRR)定价模型

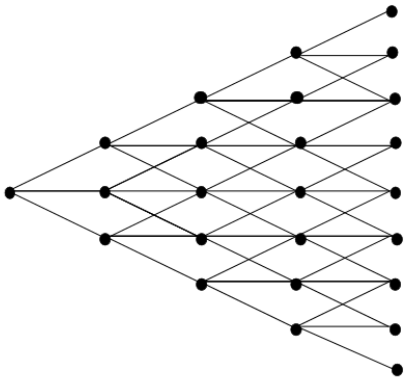
Other lattice methods其他点阵定价方法

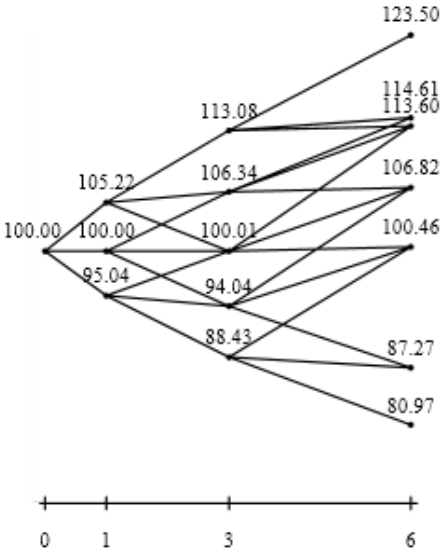
- ❑ Represents uncertainty over time as a finite sequence of possibilities
- ❑ 表示随着时间变化的不确定性（可能性有限序列）

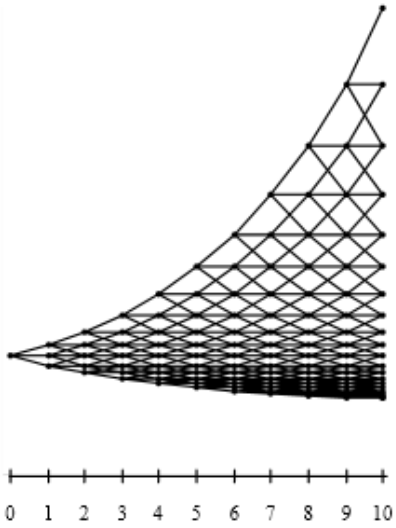
- ❑ Assumes specific jumps and transition probabilities from each state to next
- ❑ 假设从一个状态到下一个状态存在特定的跳跃和转变的可能性

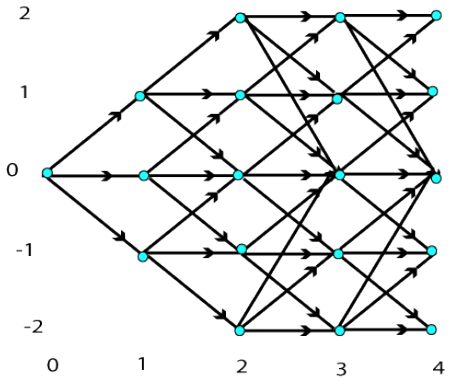
- ❑ One can increase or decrease accuracy through numerical computation
- ❑ 通过数值计算，可以增加或降低精确度

- ❑ Lends itself to well developed numerical techniques
- ❑ 适用于非常完善的数值模拟技术









Volatility波动率

- Volatility波动率
  - Historical历史波动率
  - Realized实际波动率
  - Implied隐含波动率

Volatility Smile, Skew, Smirk
波动率微笑、波动率偏离、波动率假笑

Volatility surface波动率曲面

Option valuation, replication and hedging
期权定价、复制和对冲

- Replication implies hedging; hedging implies replication
- 复制隐含对冲；对冲隐含复制
- Static vs. dynamic hedging
- 静态VS动态对冲
- Hedge ratio
- 对冲比率
- Hedge efficiency
- 对冲效率
- Minimum variance hedge:

$$OptimalHedge = \frac{PortfolioSize}{ContracSize} \bullet \rho \frac{\sigma_p}{\sigma_f}$$

- 最小方差对冲
- Hedging options
- 对冲期权

Options sensitivities (Greeks)
期权敏感度（希腊字母）

- Consider the Taylor series expansion of P/L in terms of the variables:
- 根据变量，设想盈亏值的泰勒级数展开公式：

$$\delta V(s,\sigma,r,t) = \frac{\partial V}{\partial s}\,\delta s + \frac{\partial V}{\partial \sigma}\,\delta\sigma + \frac{\partial V}{\partial r}\,\delta r + \frac{\partial V}{\partial t}\,\delta t + \frac{1}{2}\frac{\partial^2 V}{\partial s^2}\delta s^2 + \frac{1}{2}\frac{\partial^2 V}{\partial s\,\partial\sigma}\,\partial s\,\partial\sigma + \cdots$$

- Some of these derivatives have well known names, usually as Greek (or Greek sounding) letters:
- 部分变量的名称很知名，通常被称为希腊字母：
  - Commonly used: delta = $\frac{\partial V}{\partial s}$, gamma = $\frac{\partial^2 V}{\partial s^2}$, theta = $\frac{\partial V}{\partial t}$, rho = $\frac{\partial V}{\partial r}$, vega (or tau) = $\frac{\partial V}{\partial \sigma}$
  - 常用： delta= $\frac{\partial V}{\partial s}$, gamma = $\frac{\partial^2 V}{\partial s^2}$, theta = $\frac{\partial V}{\partial t}$, rho = $\frac{\partial V}{\partial r}$, vega (or tau) = $\frac{\partial V}{\partial \sigma}$
  - Less frequently used second order effects: vanna: delta-vega , omega (or vomma): vega-vega, charm: delta-theta, veta: vega-theta
  - 较少用到的二阶效应：vanna: delta-vega , omega (or vomma): vega-vega, charm: delta-theta, veta: vega-theta
  - Higher order effects: speed: delta-gamma (or delta-delta-delta), color: gama-theta, ultima: vega-vega-vega, etc.
  - 高阶效应： speed: delta-gamma (or delta-delta-delta), color: gama-theta, ultima: vega-vega-vega等

Black-Scholes Greeks
布莱克-斯科尔斯期权定价公式的希腊字母

- *s* = price; *x* = the strike price, *r* = continuously compounded risk free interest rate, *t* = time to expiration, σ = implied volatility, and Φ = the standard normal cumulative distribution function:
- *s* = 价格、*x* =行权价、*r* = 连续复合无风险利率、*t* =距离到期日的时间、σ =隐含波动率、Φ =标准正态累积分布函数:

$$\text{delta} = \Phi(d_1)$$

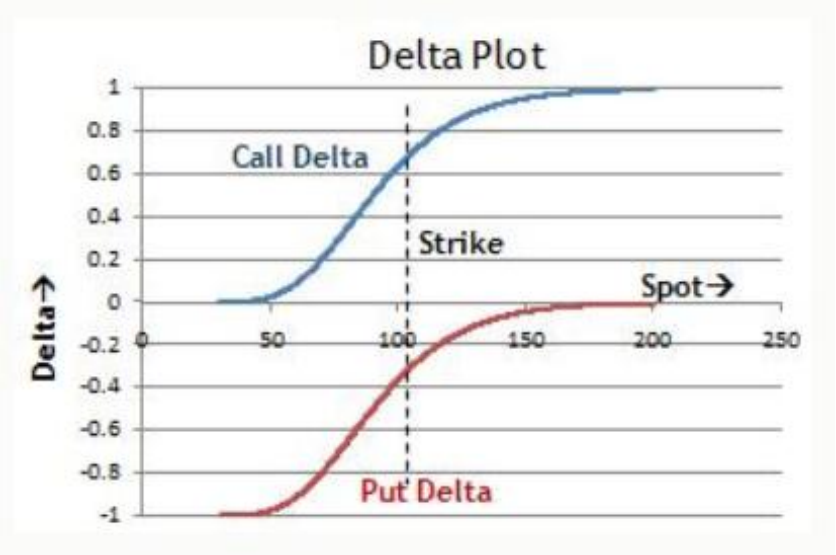
$$\text{gama} = \frac{\phi(d_1)}{s\sigma\sqrt{t}}$$

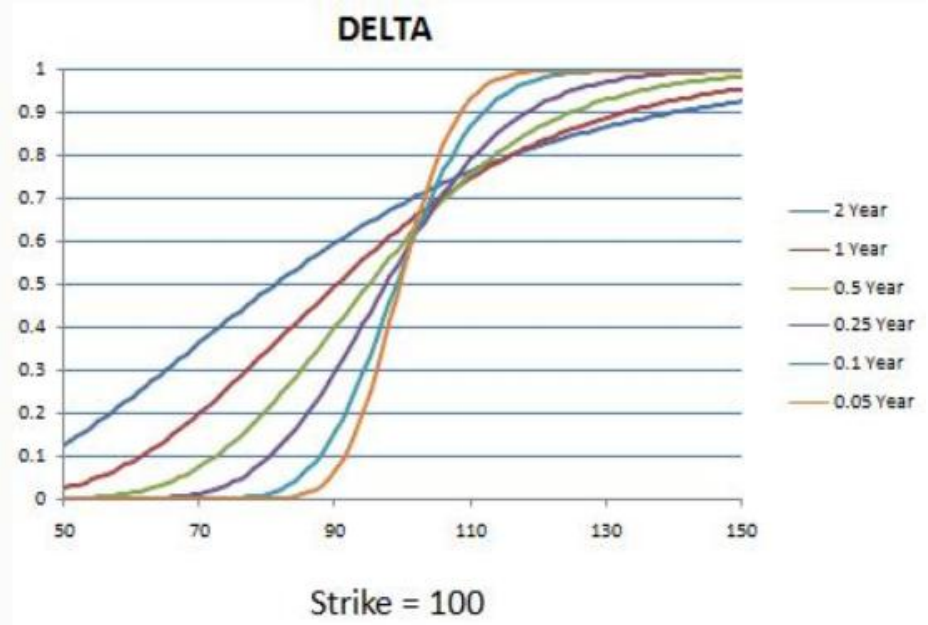
$$\text{vega} = s\phi(d_1)\sqrt{t}$$

$$\text{theta} = -\frac{s\phi(d_1)\sigma}{2\sqrt{t}} - rxe^{-rt}\Phi(d_2)$$

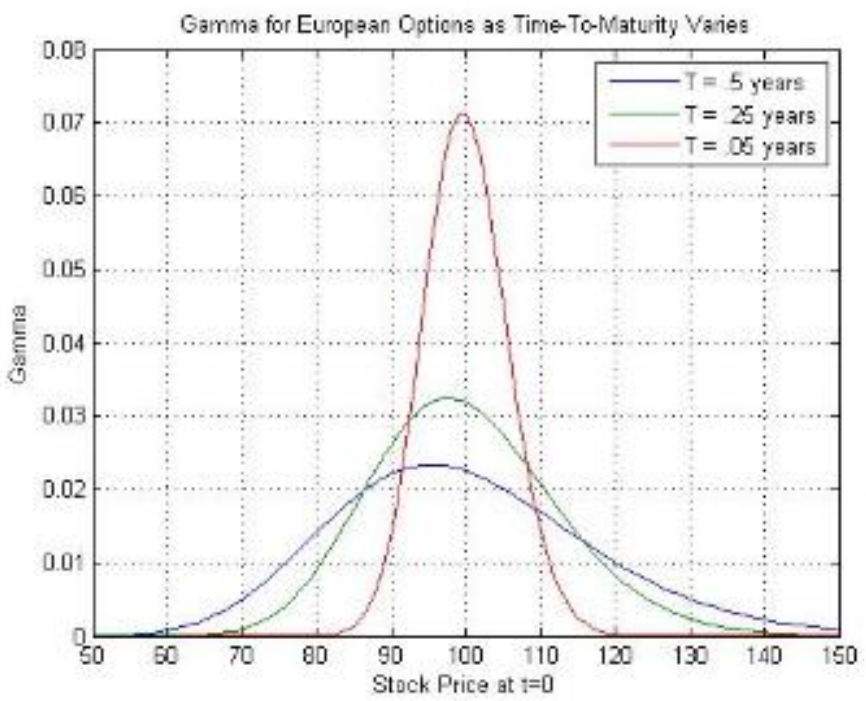
$$\text{rho} = txe^{-rt}\Phi(d_2)$$

Delta and delta hedging
Delta和delta对冲

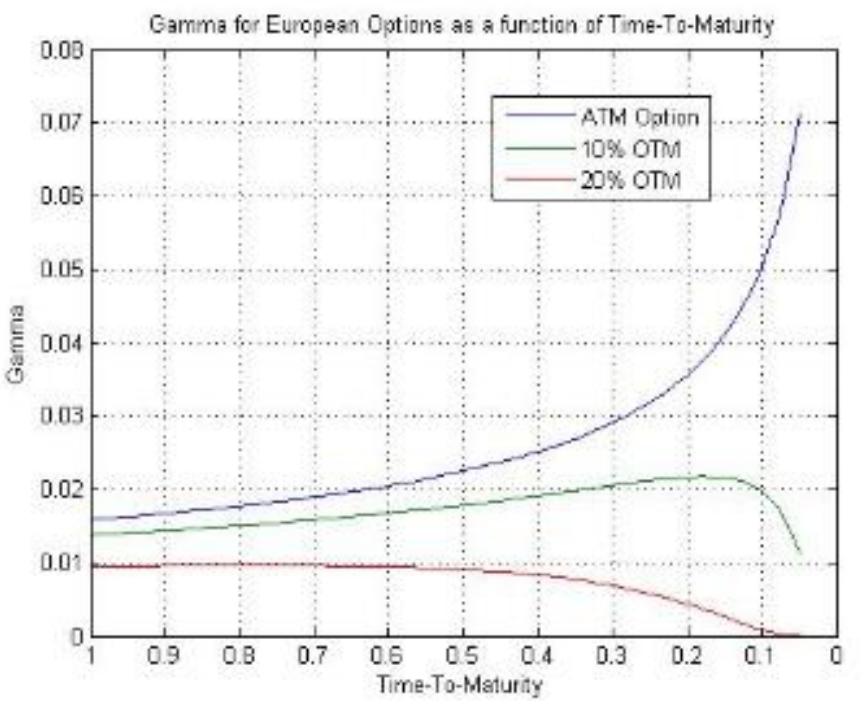




Gamma

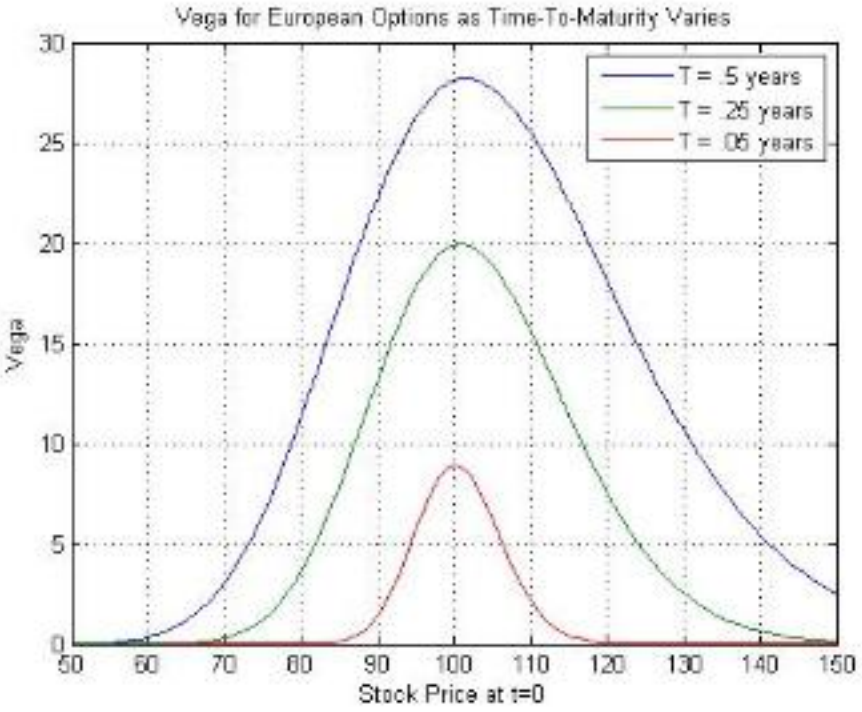


(a) Gamma as a Function of Stock Price

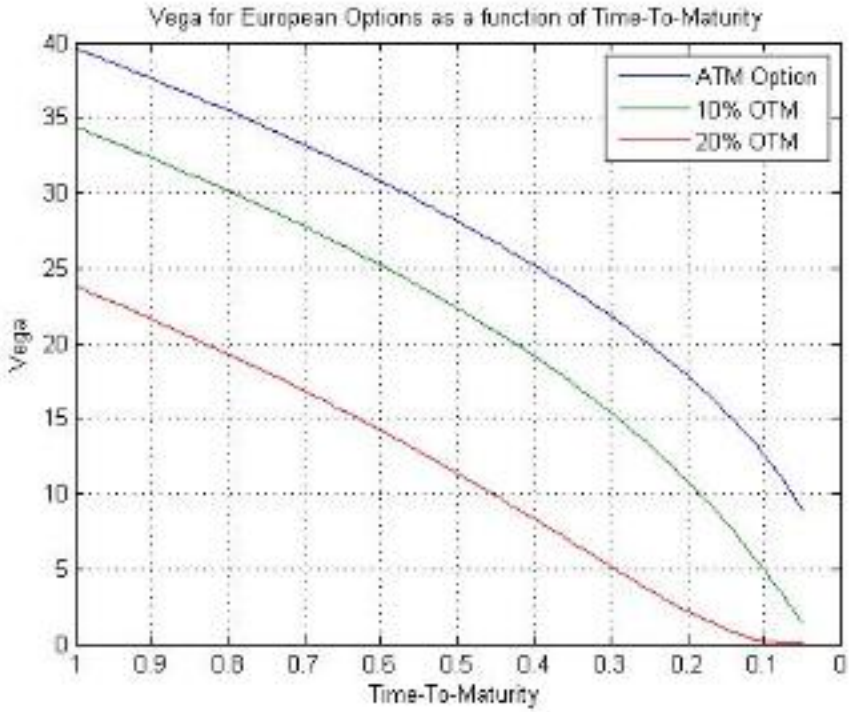


(b) Gamma as a Function of Time-to-Maturity

Vega

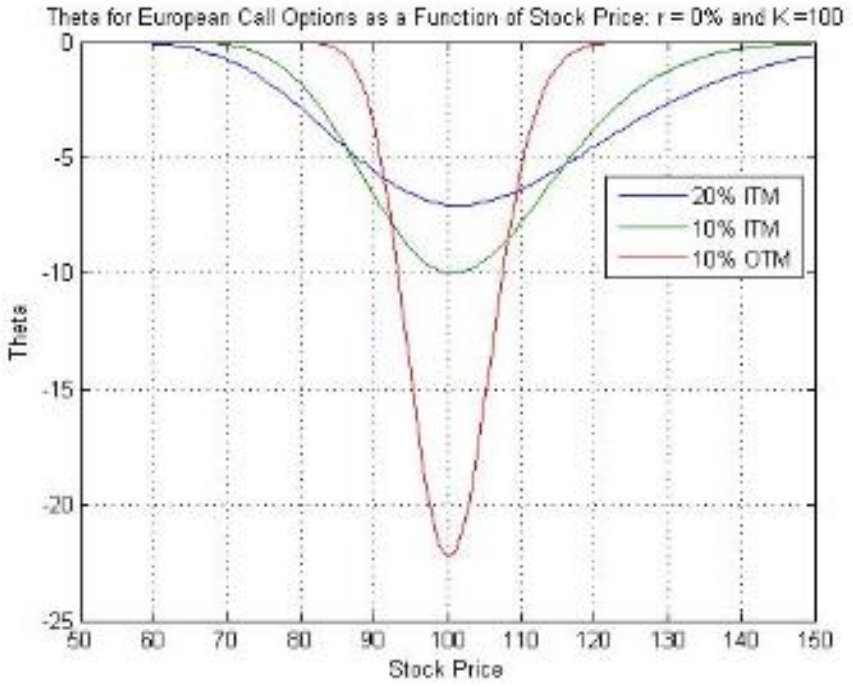


(a) Vega as a Function of Stock Price

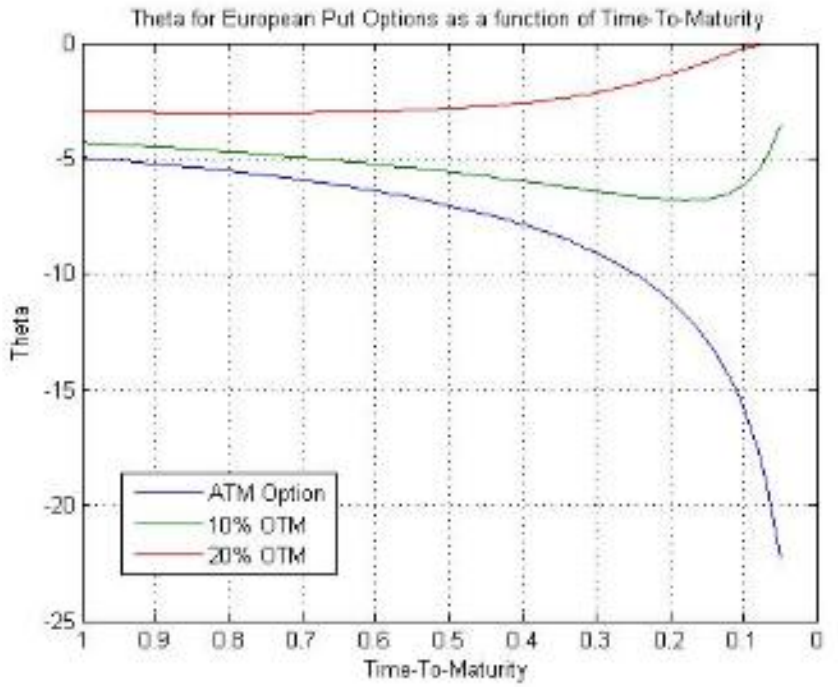


(b) Vega as a Function of Time-to-Maturity

Theta



(a) Theta as a Function of Stock Price



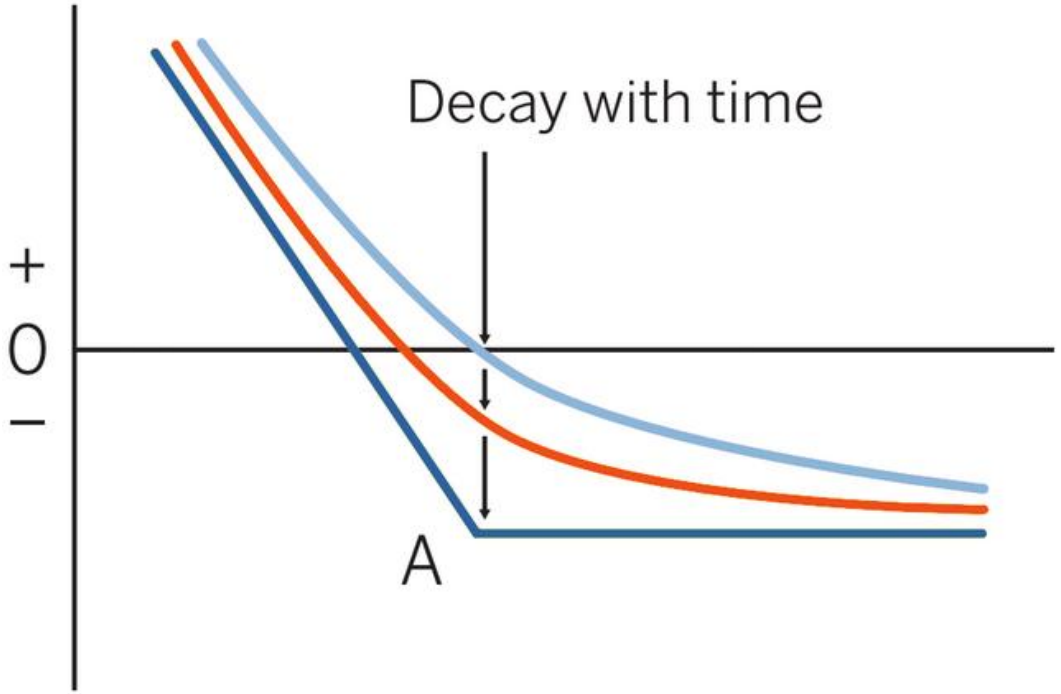
(b) Theta as a Function of Time-to-Maturity

Put-Call Parity
买卖权平价关系

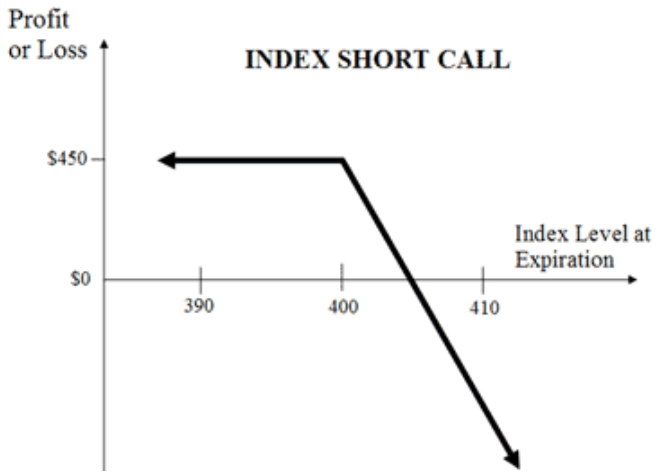
- An application of replication which states that a short put plus a long call (European and same underlying, expiration, strike) replicate a long position in the underlying asset minus the strike price. It is often used as a constraint in options pricing.
- 复制方法的应用：卖出看跌期权+买入看涨期权（欧式期权，相同标的、到期日、行权价格）= 标的多头头寸-行权价格。上述约束条件常应用于期权定价。
- Put-call parity is occasionally violated up to some arbitrage boundary due to asymmetric rules, regulations, tax treatment, liquidity and availability of the assets, etc.
- 由于不对称的规则、监管、税务、流动性和资产可用程度，买卖权平价关系有时会波动，从而产生套利机会。

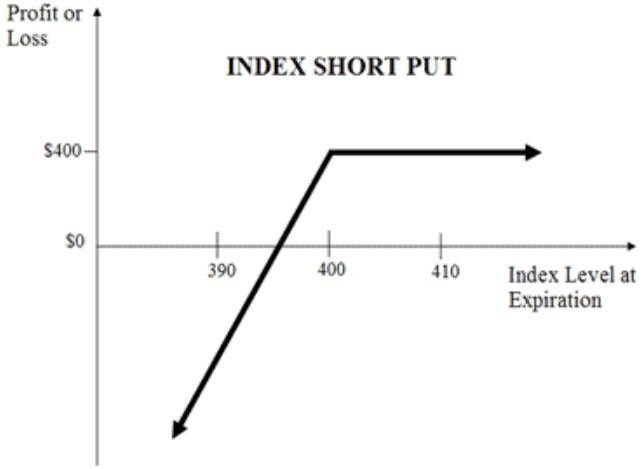
Options strategies: long call
期权策略：买入看涨期权

Options strategies: long put
期权策略：买入看跌期权

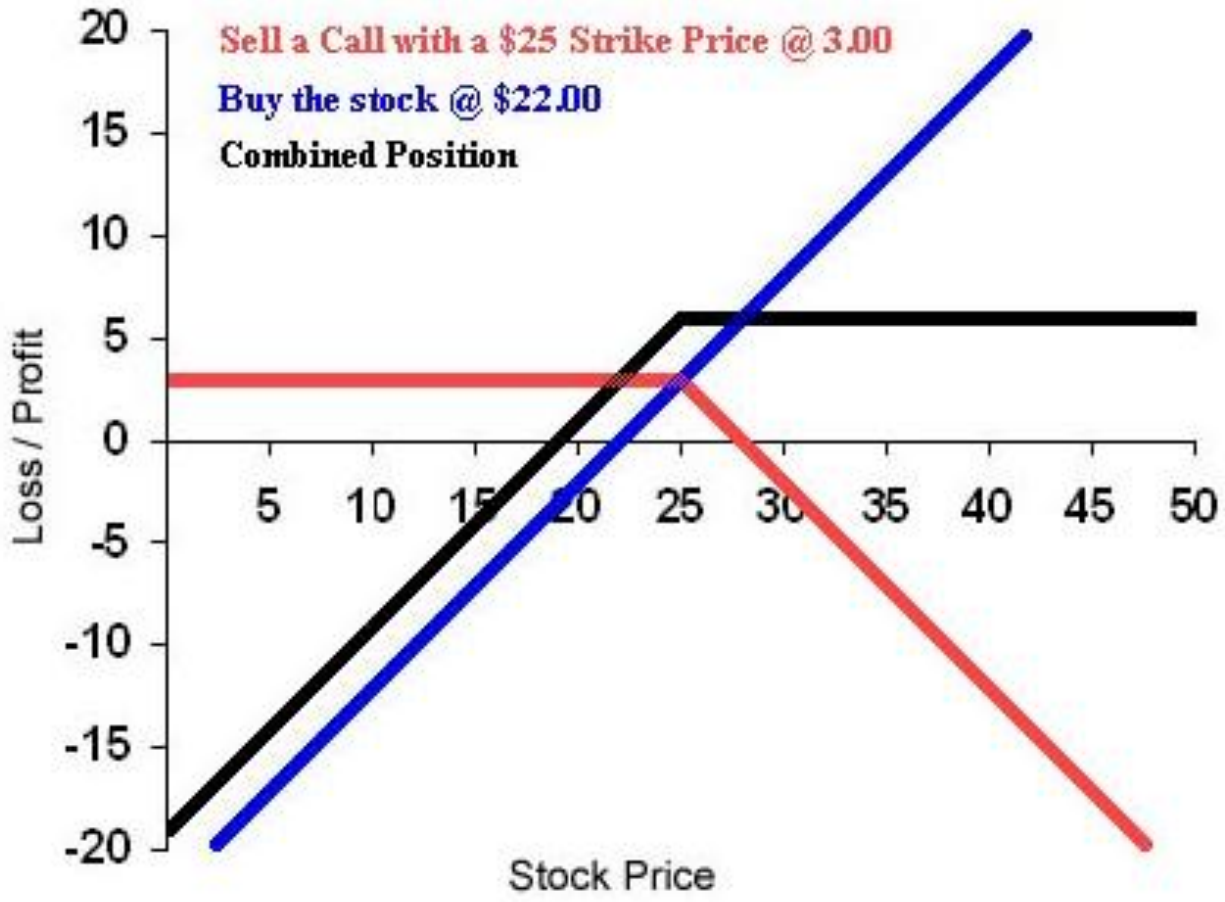


Options strategies: short call/put
期权策略：卖出看涨/看跌期权

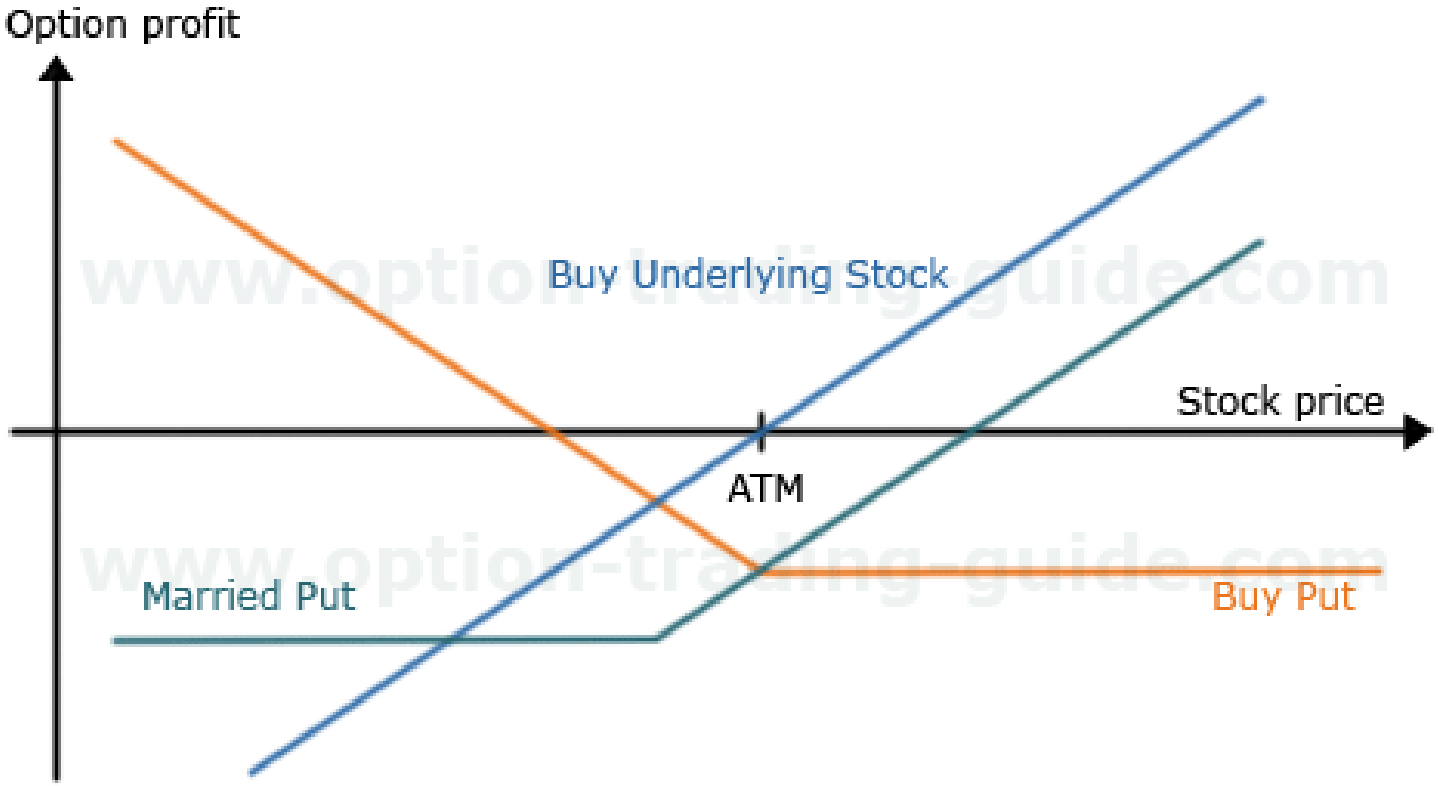




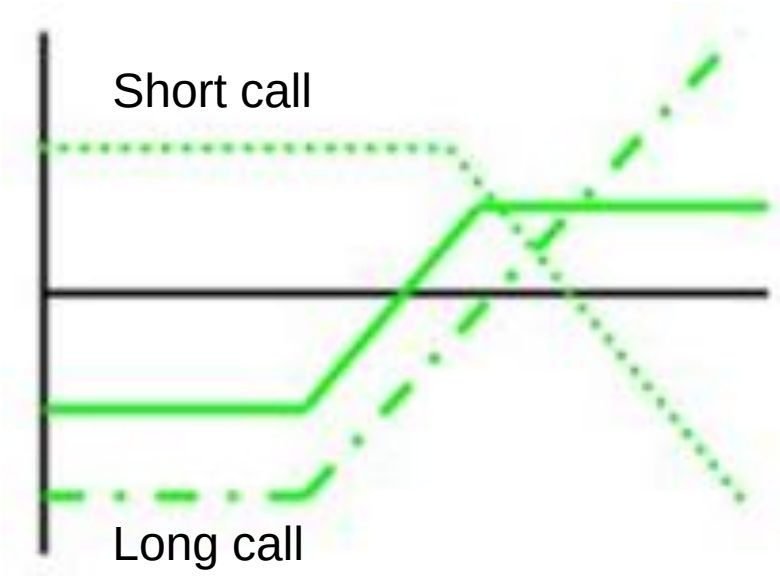
Options strategies: covered call
期权策略：对冲看涨期权

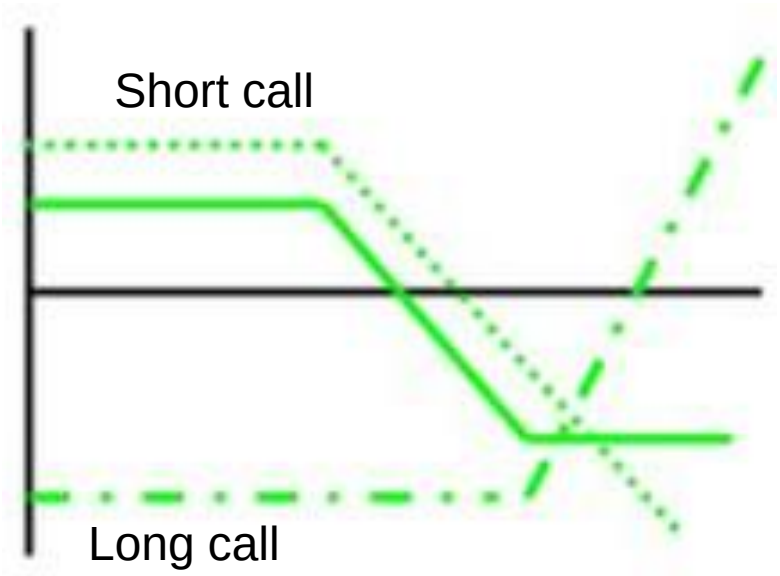


Options strategy: married put
期权策略：配对看跌期权

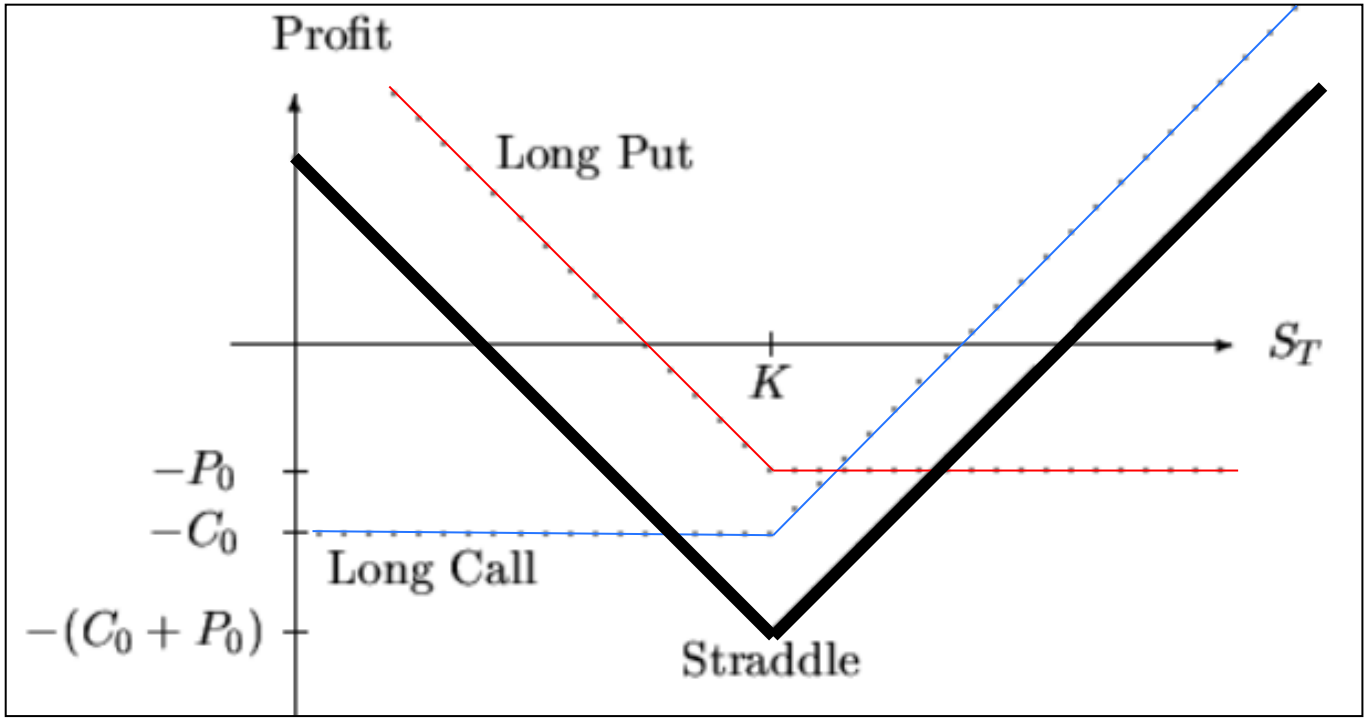


Options strategies: call spreads (bull and bear)
期权策略：看涨期权价差套利（牛市和熊市）

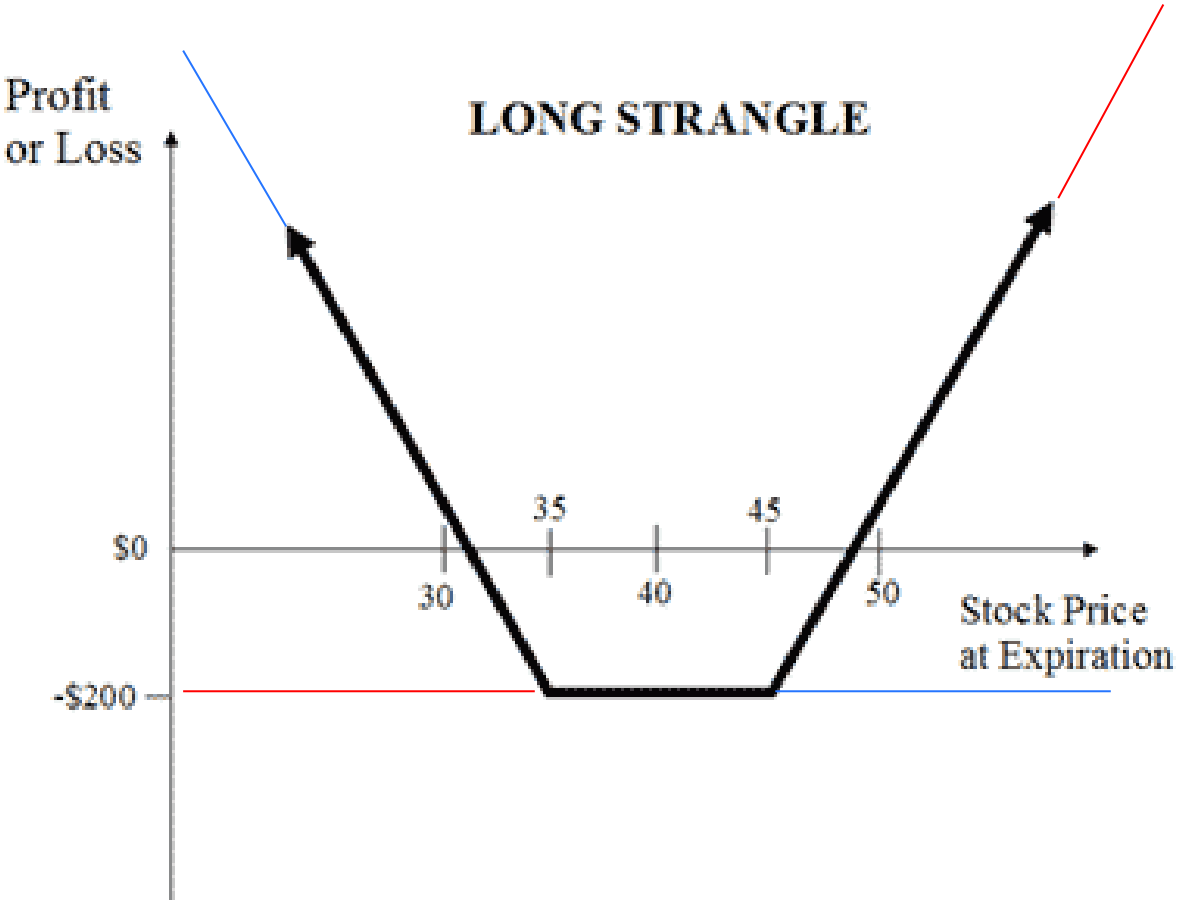




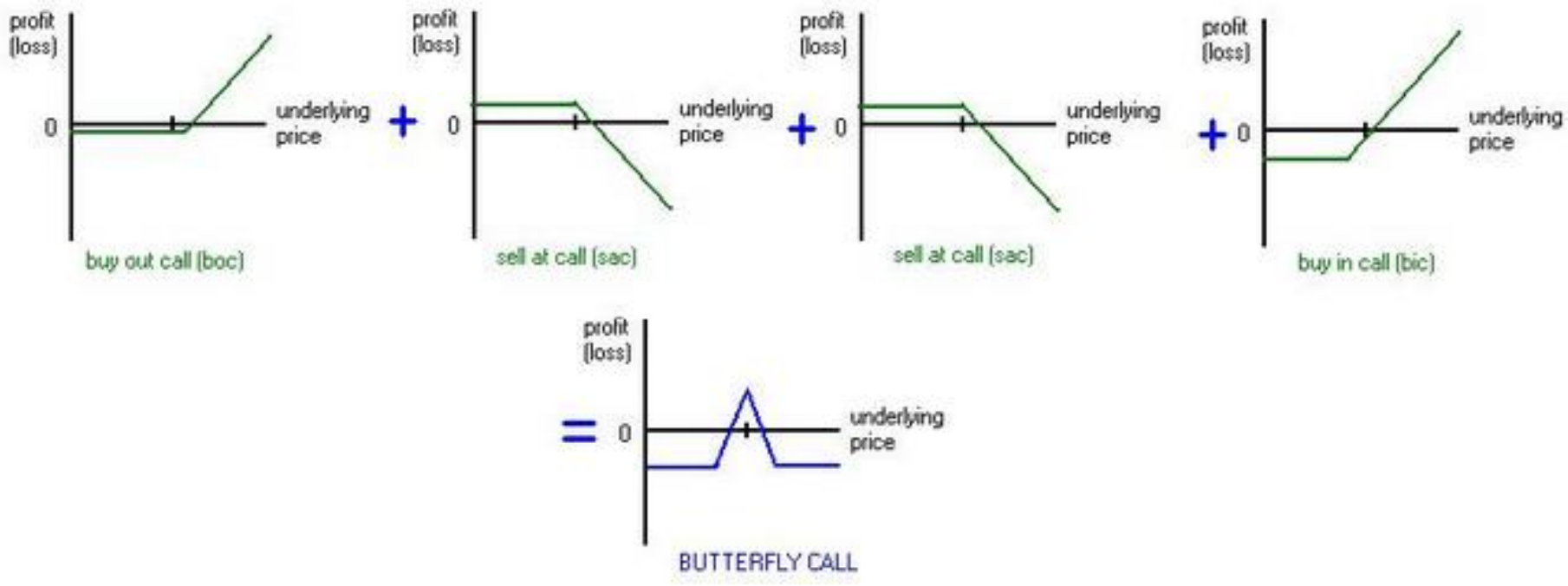
Options strategy: straddle
期权策略：跨式套利



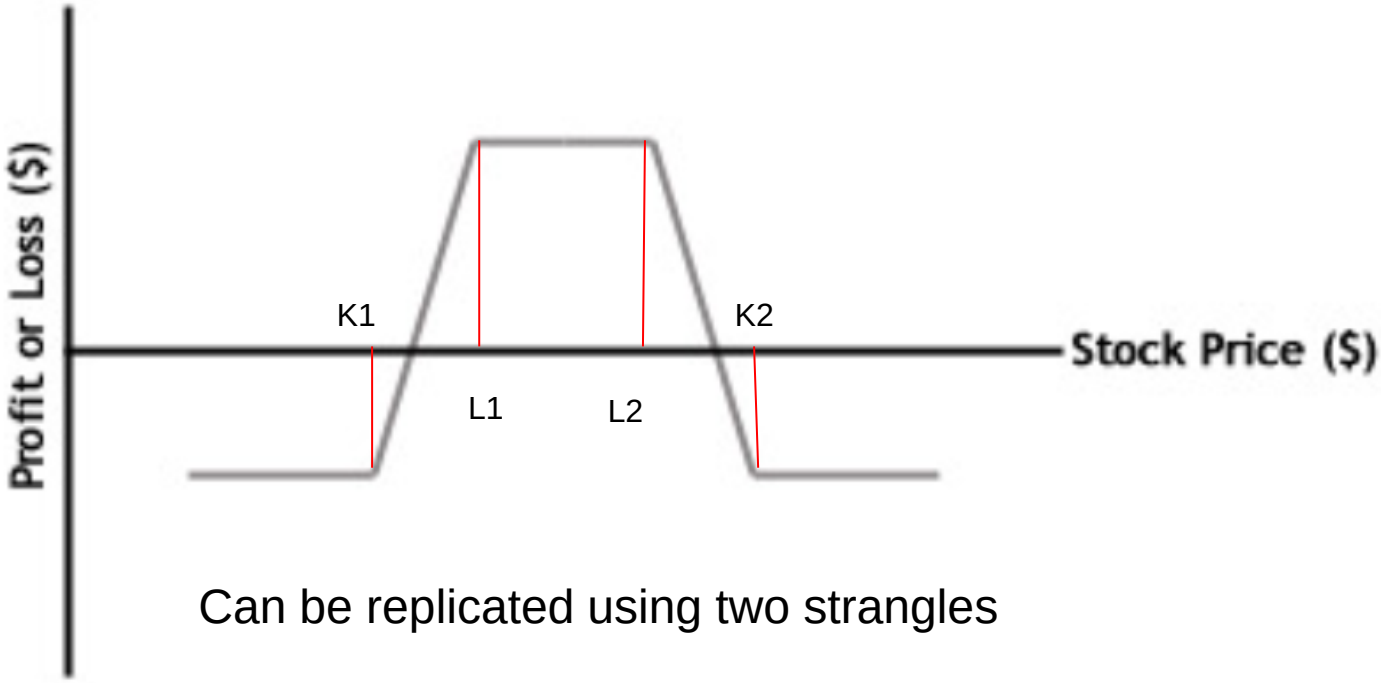
Options strategy: strangle
期权策略：宽跨式套利



Options strategy: butterfly
期权策略：蝶式套利

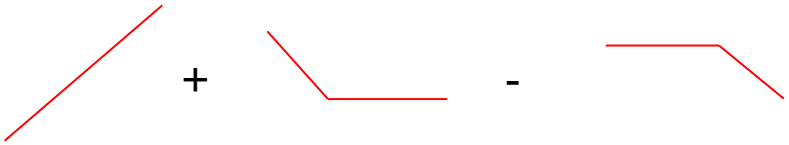


Options strategy: iron condor
期权策略：铁鹰式套利

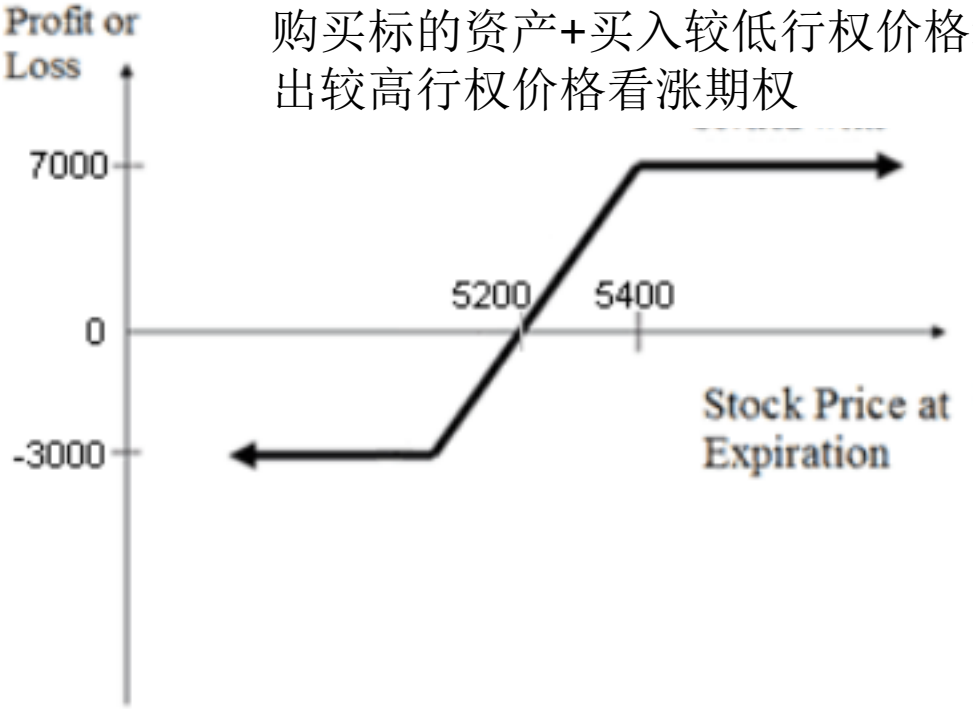


Can be replicated using two strangles

Options strategy: collar
期权策略：领子套利



Long asset + low strike put – high strike call
购买标的资产+买入较低行权价格看跌期权-卖出较高行权价格看涨期权



Options portfolio hedging期权组合对冲

- Portfolio sensitivity analysis
- 组合敏感度分析
  - Shock the portfolio with respect to underlying asset or implied volatility or time to arrive at portfolio level Greeks.
  - 分析组合的标的资产、隐含波动率及时间，计算组合的希腊字母
  - Then hedge the Greeks:
  - 然后，对冲掉希腊字母风险：
    - Delta can be hedged with the underlying instruments
    - Delta可以使用标的工具对冲
    - Vega can be hedged without introducing additional delta (straddles and strangles)
    - Vega可以通过避免引入Delta的方式对冲（跨式组合和宽跨式组合）
    - Gamma and time decay can be hedged/adjusted using combinations of straddles (different expiries) and strangles
    - Gamma和时间衰减可以使用跨式组合（不同到期日）和宽跨式组合的组合进行对冲/调整
    - Dynamic hedging of options portfolios is expensive and minimizing dynamic hedging costs is crucial
    - 期权组合的动态对冲方式成本很高，因此将该成本最小化很关键

Options portfolio hedging期权组合对冲

- Sensitivity analysis (slides)
- 敏感度分析（平滑）
  - Options payoff profiles and sensitivities are inherently nonlinear. To have a better handle on the risks of a portfolio often sensitivity analysis is repeated at multiple values so that the nonlinearities are identified and understood
  - 期权的收益曲线和敏感度具有内在非线性特征。为了更好管理组合风险，需要经常对大量数据反复进行敏感度分析，从而识别并理解这些非线性特征
- Scenario analysis
- 情景仿真分析
  - Another risk management tool is to put the portfolio through certain historical scenarios involving unusual and abnormal market moves.
  - 另一种风险管理工具是将组合放入到某些涉及异常市场波动的历史情景中
  - In addition to market moves, simulations involving liquidity and access to liquidity are often very useful in understanding risks
  - 除了市场波动，对涉及流动性和流动性可用性方面的模拟对理解风险也非常有用

Final remarks最后点评

- More on options pricing
- 更多期权定价模型

- Fast options pricing for market making
- 适用于做市的快速期权定价

- How's the hedging done in practice?
- 实践中，如何实现对冲？

KCG

Thank you