



# VALUATION: PACKET 3 REAL OPTIONS, ACQUISITION VALUATION AND VALUE ENHANCEMENT



# REAL OPTIONS: FACT AND FANTASY

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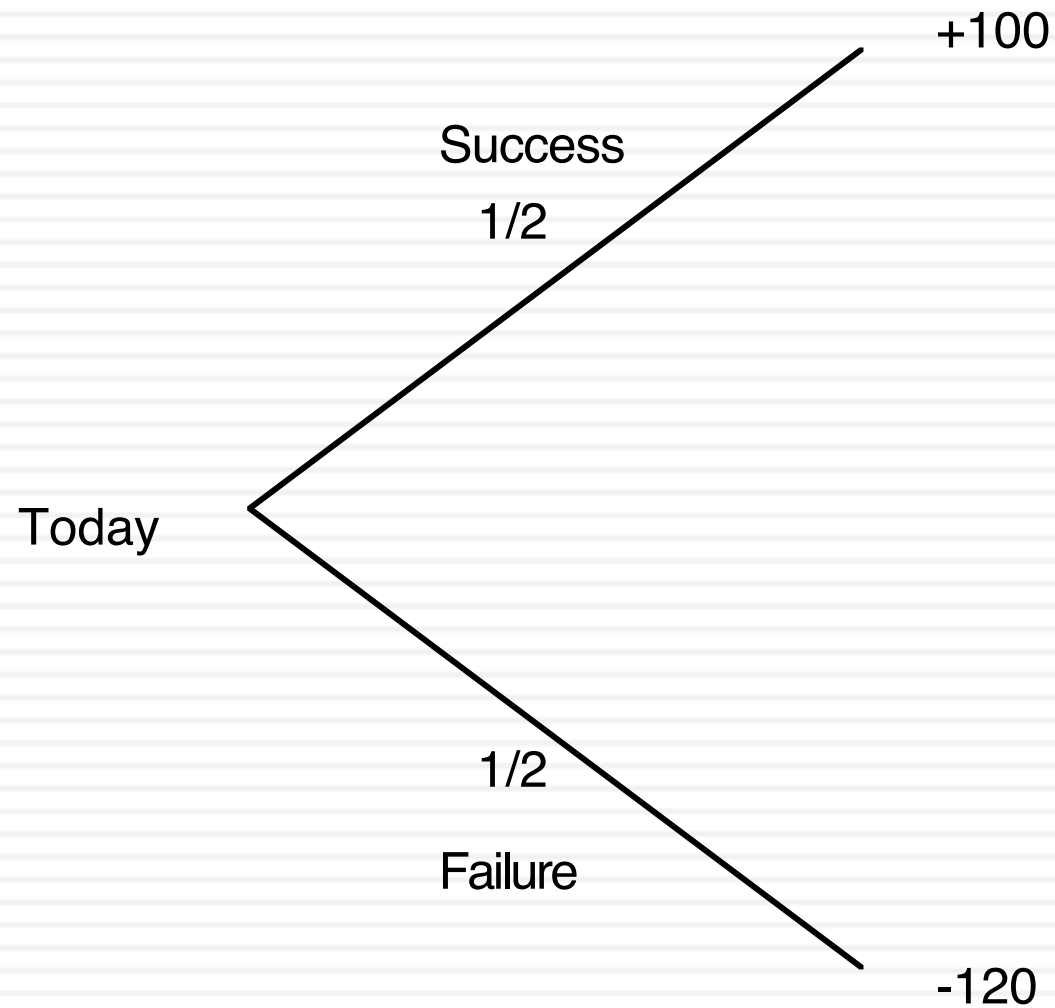
# Underlying Theme: Searching for an Elusive Premium

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- Traditional discounted cashflow models under estimate the value of investments, where there are options embedded in the investments to
  - ▣ Delay or defer making the investment (delay)
  - ▣ Adjust or alter production schedules as price changes (flexibility)
  - ▣ Expand into new markets or products at later stages in the process, based upon observing favorable outcomes at the early stages (expansion)
  - ▣ Stop production or abandon investments if the outcomes are unfavorable at early stages (abandonment)
- Put another way, real option advocates believe that you should be paying a premium on discounted cashflow value estimates.

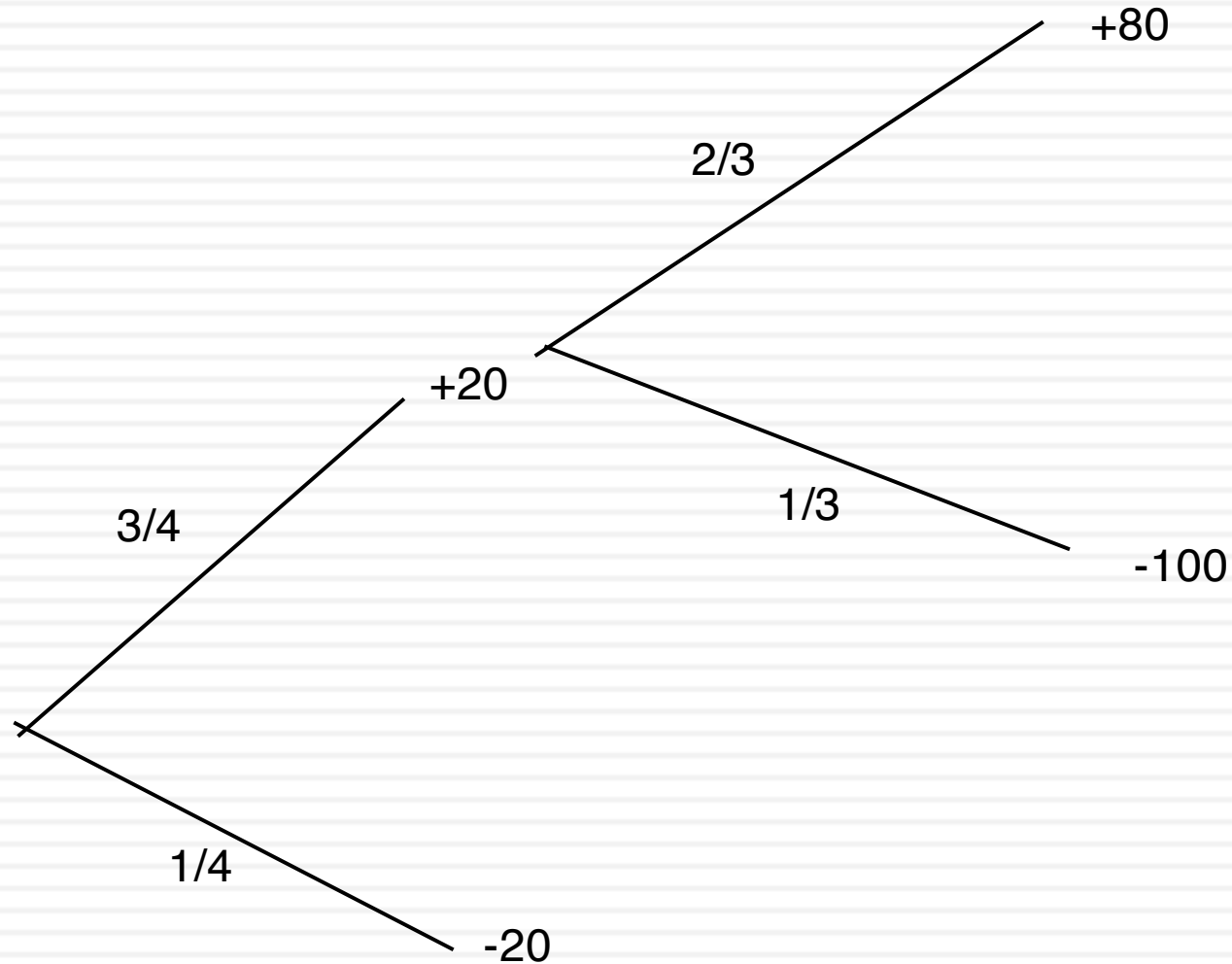
# A bad investment...

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# Becomes a good one...

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# Three Basic Questions

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- When is there a real option embedded in a decision or an asset?
- When does that real option have significant economic value?
- Can that value be estimated using an option pricing model?

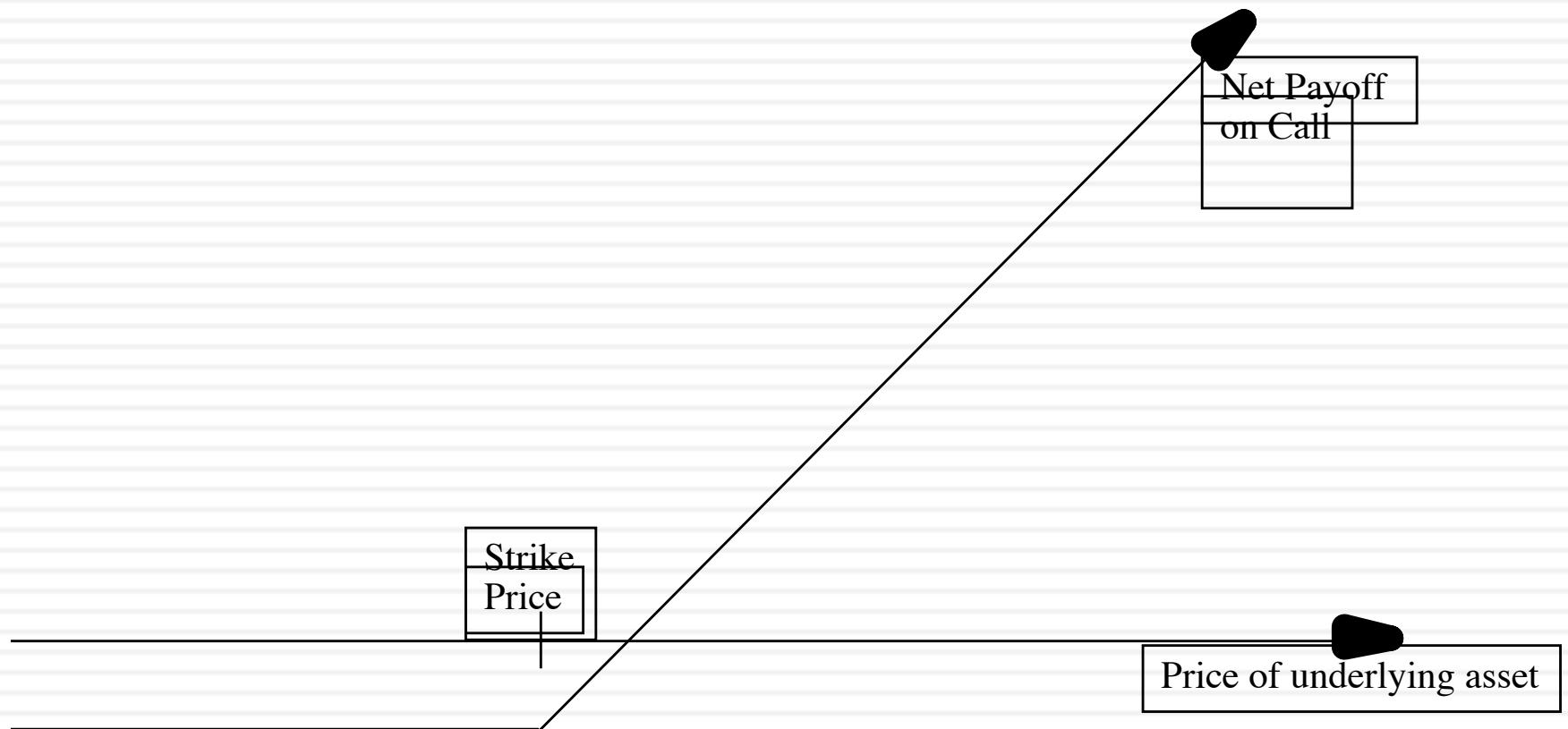
# When is there an option embedded in an action?

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- An option provides the holder with the right to buy or sell a specified quantity of an underlying asset at a fixed price (called a strike price or an exercise price) at or before the expiration date of the option.
- There has to be a clearly defined underlying asset whose value changes over time in unpredictable ways.
- The payoffs on this asset (real option) have to be contingent on an specified event occurring within a finite period.

# Payoff Diagram on a Call

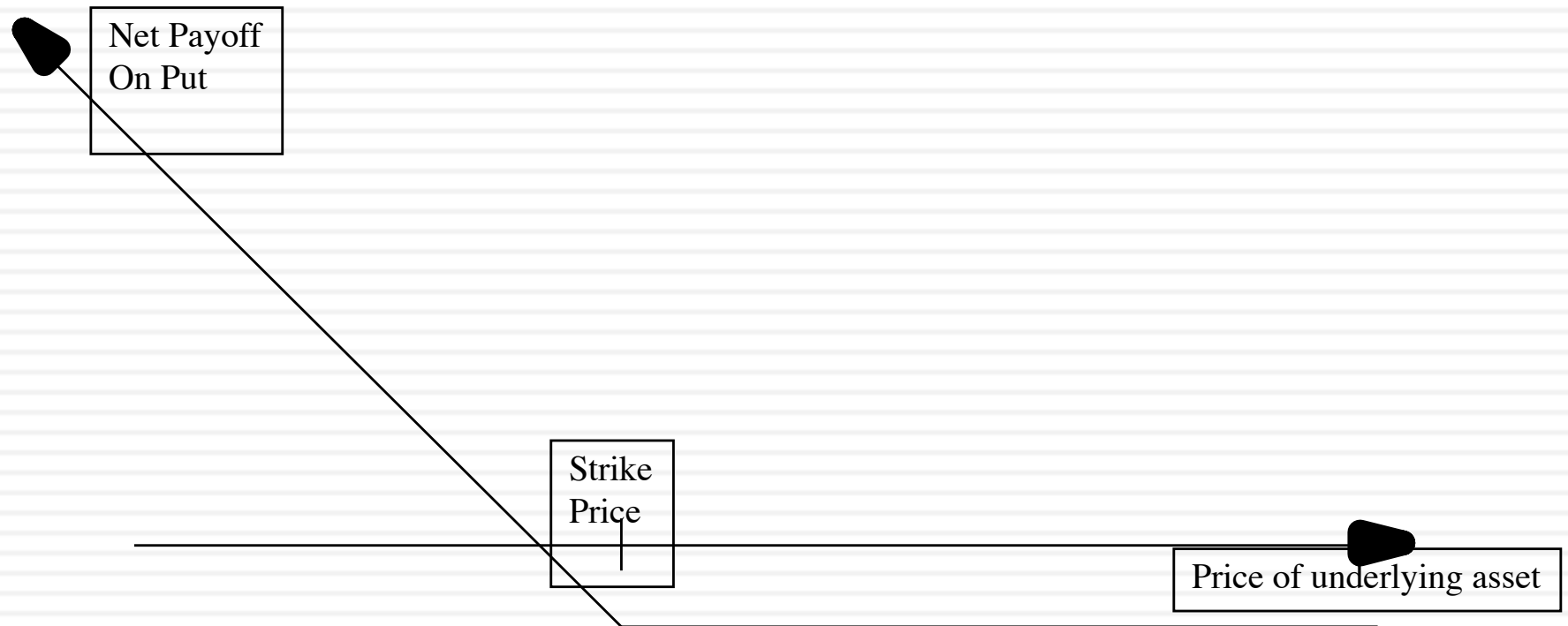
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# Payoff Diagram on Put Option

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# When does the option have significant economic value?

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- For an option to have significant economic value, there has to be a restriction on competition in the event of the contingency. In a perfectly competitive product market, no contingency, no matter how positive, will generate positive net present value.
- At the limit, real options are most valuable when you have exclusivity - you and only you can take advantage of the contingency. They become less valuable as the barriers to competition become less steep.

# Determinants of option value

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- Variables Relating to Underlying Asset
  - Value of Underlying Asset; as this value increases, the right to buy at a fixed price (calls) will become more valuable and the right to sell at a fixed price (puts) will become less valuable.
  - Variance in that value; as the variance increases, both calls and puts will become more valuable because all options have limited downside and depend upon price volatility for upside.
  - Expected dividends on the asset, which are likely to reduce the price appreciation component of the asset, reducing the value of calls and increasing the value of puts.
- Variables Relating to Option
  - Strike Price of Options; the right to buy (sell) at a fixed price becomes more (less) valuable at a lower price.
  - Life of the Option; both calls and puts benefit from a longer life.
- Level of Interest Rates; as rates increase, the right to buy (sell) at a fixed price in the future becomes more (less) valuable.

# When can you use option pricing models to value real options?

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- The notion of a replicating portfolio that drives option pricing models makes them most suited for valuing real options where
  - ▣ The underlying asset is traded - this yields not only observable prices and volatility as inputs to option pricing models but allows for the possibility of creating replicating portfolios
  - ▣ An active marketplace exists for the option itself.
  - ▣ The cost of exercising the option is known with some degree of certainty.
- When option pricing models are used to value real assets, we have to accept the fact that
  - ▣ The value estimates that emerge will be far more imprecise.
  - ▣ The value can deviate much more dramatically from market price because of the difficulty of arbitrage.

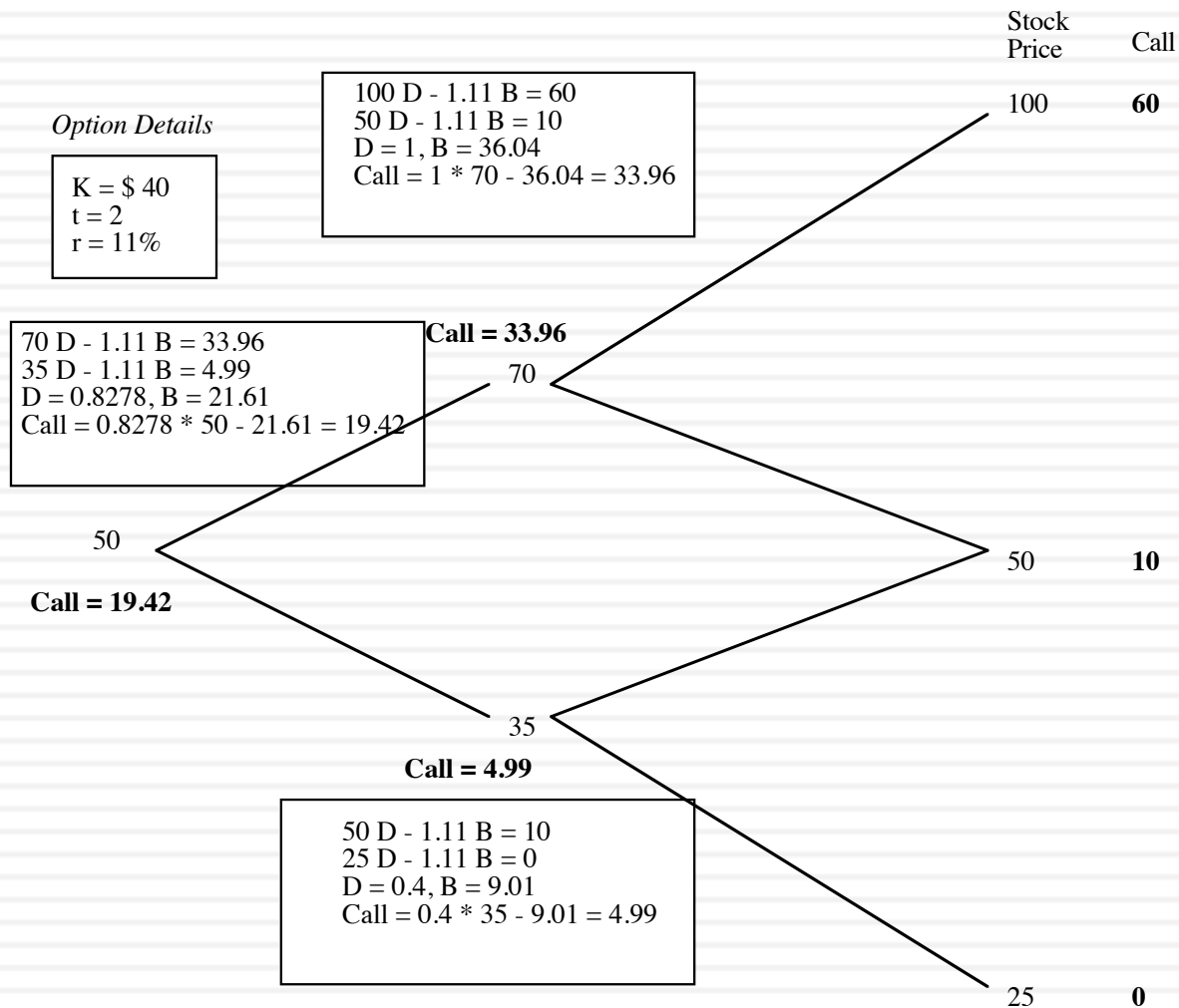
# Creating a replicating portfolio

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- The objective in creating a replicating portfolio is to use a combination of riskfree borrowing/lending and the underlying asset to create the same cashflows as the option being valued.
  - ▣ Call = Borrowing + Buying  $D$  of the Underlying Stock
  - ▣ Put = Selling Short  $D$  on Underlying Asset + Lending
  - ▣ The number of shares bought or sold is called the option delta.
- The principles of arbitrage then apply, and the value of the option has to be equal to the value of the replicating portfolio.

# The Binomial Option Pricing Model

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# The Limiting Distributions....

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- As the time interval is shortened, the limiting distribution, as  $t \rightarrow 0$ , can take one of two forms.
  - If as  $t \rightarrow 0$ , price changes become smaller, the limiting distribution is the normal distribution and the price process is a continuous one.
  - If as  $t \rightarrow 0$ , price changes remain large, the limiting distribution is the poisson distribution, i.e., a distribution that allows for price jumps.
- The Black-Scholes model applies when the limiting distribution is the normal distribution, and explicitly assumes that the price process is continuous and that there are no jumps in asset prices.

# Black and Scholes...

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- The version of the model presented by Black and Scholes was designed to value European options, which were dividend-protected.
- The value of a call option in the Black-Scholes model can be written as a function of the following variables:
  - ▣  $S$  = Current value of the underlying asset
  - ▣  $K$  = Strike price of the option
  - ▣  $t$  = Life to expiration of the option
  - ▣  $r$  = Riskless interest rate corresponding to the life of the option
  - ▣  $\sigma^2$  = Variance in the  $\ln(\text{value})$  of the underlying asset



# The Black Scholes Model

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Value of call =  $S N(d_1) - K e^{-rt} N(d_2)$

where

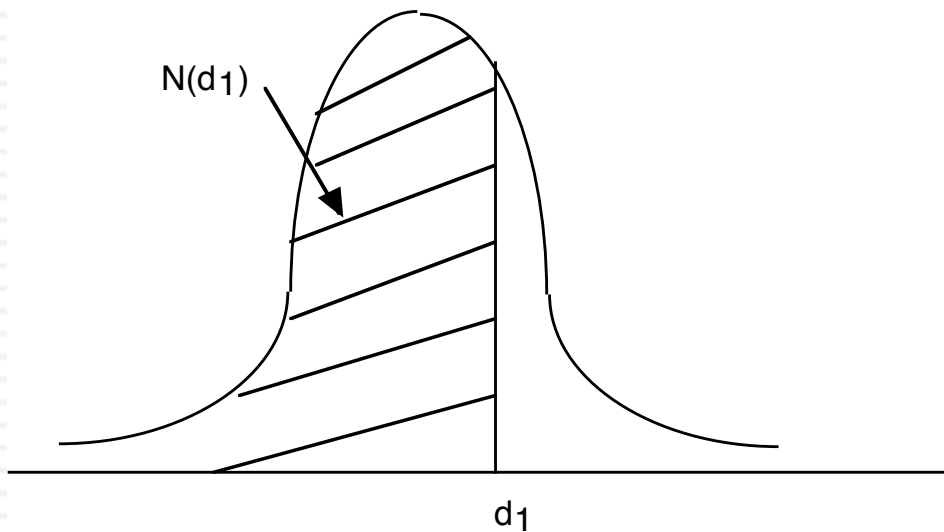
$$d_1 = \frac{\ln\left(\frac{S}{K}\right) + \left(r + \frac{\sigma^2}{2}\right) t}{\sigma \sqrt{t}}$$

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

- The replicating portfolio is embedded in the Black-Scholes model. To replicate this call, you would need to
  - Buy  $N(d_1)$  shares of stock;  $N(d_1)$  is called the option delta
  - Borrow  $K e^{-rt} N(d_2)$

# The Normal Distribution

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$d$	$N(d)$	$d$	$N(d)$	$d$	$N(d)$
-3.00	0.0013	-1.00	0.1587	1.05	0.8531
-2.95	0.0016	-0.95	0.1711	1.10	0.8643
-2.90	0.0019	-0.90	0.1841	1.15	0.8749
-2.85	0.0022	-0.85	0.1977	1.20	0.8849
-2.80	0.0026	-0.80	0.2119	1.25	0.8944
-2.75	0.0030	-0.75	0.2266	1.30	0.9032
-2.70	0.0035	-0.70	0.2420	1.35	0.9115
-2.65	0.0040	-0.65	0.2578	1.40	0.9192
-2.60	0.0047	-0.60	0.2743	1.45	0.9265
-2.55	0.0054	-0.55	0.2912	1.50	0.9332
-2.50	0.0062	-0.50	0.3085	1.55	0.9394
-2.45	0.0071	-0.45	0.3264	1.60	0.9452
-2.40	0.0082	-0.40	0.3446	1.65	0.9505
-2.35	0.0094	-0.35	0.3632	1.70	0.9554
-2.30	0.0107	-0.30	0.3821	1.75	0.9599
-2.25	0.0122	-0.25	0.4013	1.80	0.9641
-2.20	0.0139	-0.20	0.4207	1.85	0.9678
-2.15	0.0158	-0.15	0.4404	1.90	0.9713
-2.10	0.0179	-0.10	0.4602	1.95	0.9744
-2.05	0.0202	-0.05	0.4801	2.00	0.9772
-2.00	0.0228	0.00	0.5000	2.05	0.9798
-1.95	0.0256	0.05	0.5199	2.10	0.9821
-1.90	0.0287	0.10	0.5398	2.15	0.9842
-1.85	0.0322	0.15	0.5596	2.20	0.9861
-1.80	0.0359	0.20	0.5793	2.25	0.9878
-1.75	0.0401	0.25	0.5987	2.30	0.9893
-1.70	0.0446	0.30	0.6179	2.35	0.9906
-1.65	0.0495	0.35	0.6368	2.40	0.9918
-1.60	0.0548	0.40	0.6554	2.45	0.9929
-1.55	0.0606	0.45	0.6736	2.50	0.9938
-1.50	0.0668	0.50	0.6915	2.55	0.9946
-1.45	0.0735	0.55	0.7088	2.60	0.9953
-1.40	0.0808	0.60	0.7257	2.65	0.9960
-1.35	0.0885	0.65	0.7422	2.70	0.9965
-1.30	0.0968	0.70	0.7580	2.75	0.9970
-1.25	0.1056	0.75	0.7734	2.80	0.9974
-1.20	0.1151	0.80	0.7881	2.85	0.9978
-1.15	0.1251	0.85	0.8023	2.90	0.9981
-1.10	0.1357	0.90	0.8159	2.95	0.9984
-1.05	0.1469	0.95	0.8289	3.00	0.9987
-1.00	0.1587	1.00	0.8413		

# Adjusting for Dividends

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- If the dividend yield ( $y = \text{dividends} / \text{Current value of the asset}$ ) of the underlying asset is expected to remain unchanged during the life of the option, the Black-Scholes model can be modified to take dividends into account.

- $C = S e^{-yt} N(d_1) - K e^{-rt} N(d_2)$

where,

$$d_1 = \frac{\ln\left(\frac{S}{K}\right) + \left(r - y + \frac{\sigma^2}{2}\right) t}{\sigma \sqrt{t}}$$

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

- The value of a put can also be derived:
- $P = K e^{-rt} (1 - N(d_2)) - S e^{-yt} (1 - N(d_1))$

# Choice of Option Pricing Models

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- Most practitioners who use option pricing models to value real options argue for the binomial model over the Black-Scholes and justify this choice by noting that
  - ▣ Early exercise is the rule rather than the exception with real options
  - ▣ Underlying asset values are generally discontinuous.
- If you can develop a binomial tree with outcomes at each node, it looks a great deal like a decision tree from capital budgeting. The question then becomes when and why the two approaches yield different estimates of value.

# The Decision Tree Alternative

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- Traditional decision tree analysis tends to use
  - ▣ One cost of capital to discount cashflows in each branch to the present
  - ▣ Probabilities to compute an expected value
  - ▣ These values will generally be different from option pricing model values
- If you modified decision tree analysis to
  - ▣ Use different discount rates at each node to reflect where you are in the decision tree (This is the Copeland solution) (or)
  - ▣ Use the riskfree rate to discount cashflows in each branch, estimate the probabilities to estimate an expected value and adjust the expected value for the market risk in the investment
- Decision Trees could yield the same values as option pricing models

# A decision tree valuation of a pharmaceutical company with one drug in the FDA pipeline...

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