Solvay Brussels School
Economics & Management

ULB

Corporate Valuation and Financing
Real Options

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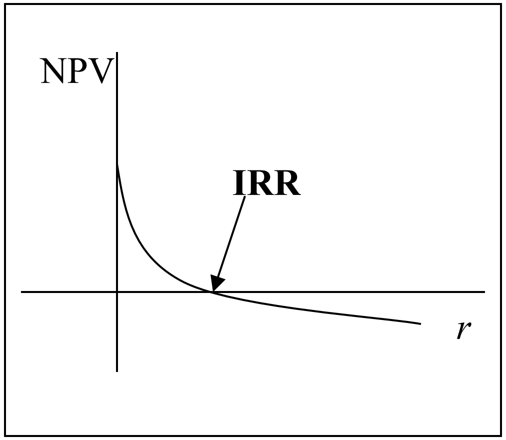
Typical project valuation approaches

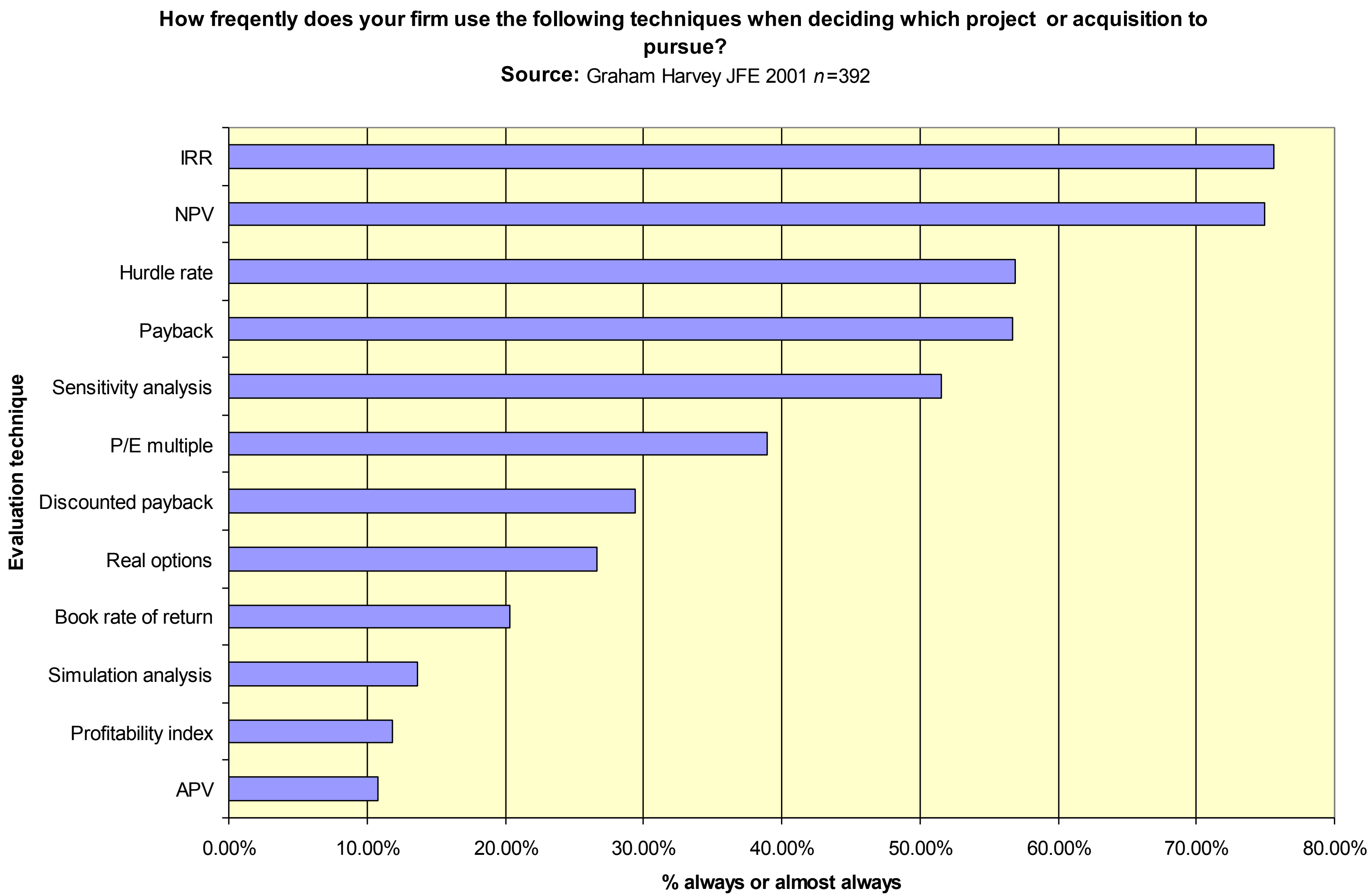
Investment rules

- Net Present Value (NPV)
  - Discounted incremental free cash flows
  - Rule: invest if NPV>0
- Internal Rate of Return (IRR)
  - IRR: discount rate such that NPV=0
  - Rule: invest if IRR > Cost of capital

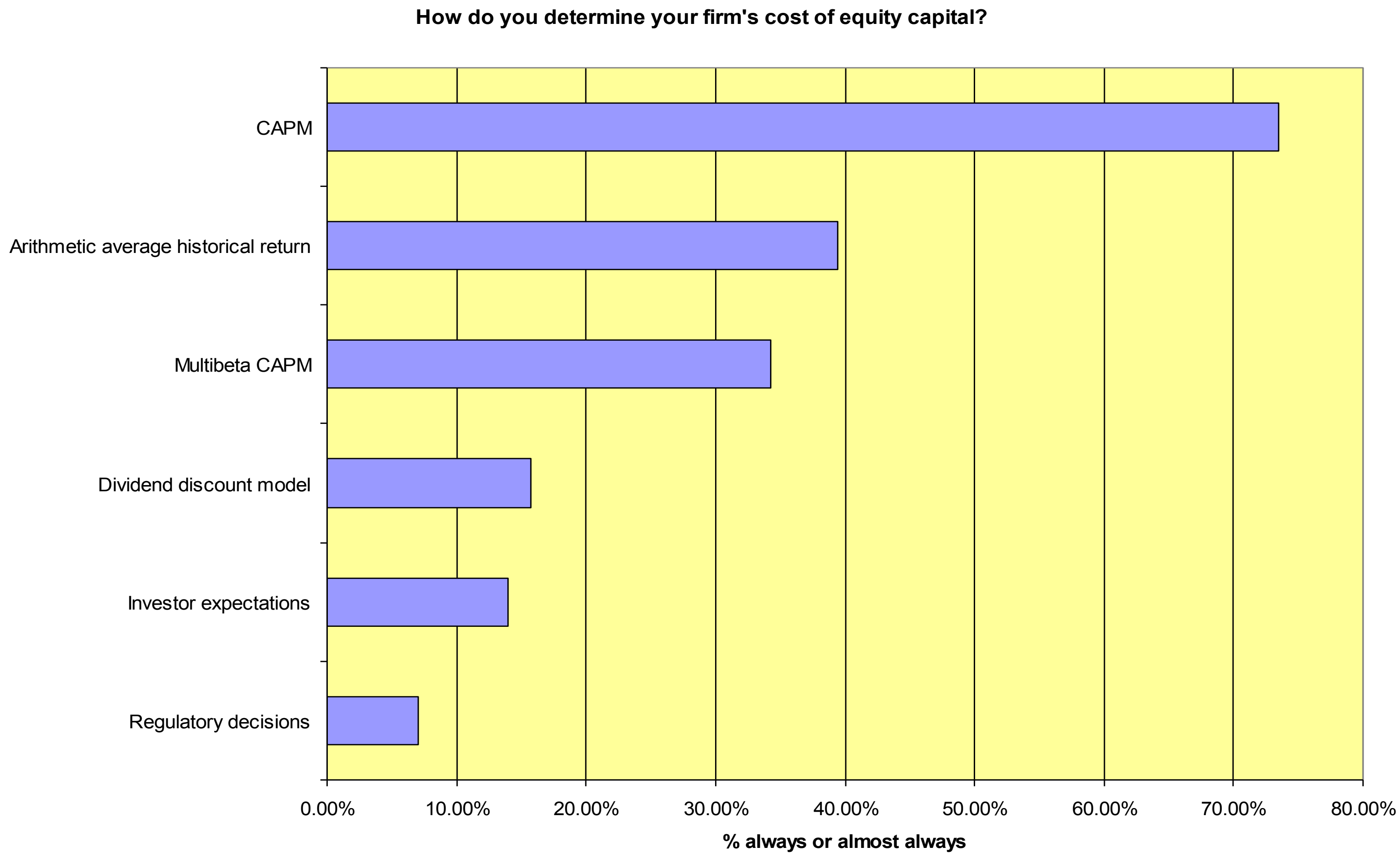


- Payback period
  - Numbers of year to recoup initial investment
  - No precise rule
- Profitability Index (PI)
  - PI = NPV / Investment
  - Useful to rank projects if capital spending is limited

What do CFOs Use? – Capital budgeting (2)



What do CFOs Use? – Cost of Equity



Statements

- Definitions...
  - » Economist view: « investment is the act of incurring an immediate cost in the expectation of future rewards »
    - ✓ Firm that constructs plant, install equipment
    - ✓ Shutting down a loss-making plant
    - → Investment decisions are ubiquitous...
  - » Most investment decisions are based on...
    - ✓ An irreversible investment decision (initial layout is partly a sunk)
    - ✓ Uncertainty about future outcomes → you can assess some probas
    - ✓ Some timing → you can postpone decisions to get more info but never complete certainty
    - → Interactions between these three features

The Orthodox Theory

- Economic idea:
  - Invest up to the point where the value of an incremental unit of capital equals its cost
- Evidence
  - Real world investments seem to be
    - ✓ Less sensitive to interest-rate changes and tax policy changes
    - ✓ More sensitive to volatility and uncertainty in the environment
  - Non-economic decisions seem impossible to quantify
- Approach
  - Compute NPV
  - If NPV>0, go for it!
- Special features
  - Estimations of expectations
  - Treatment of inflation

The Orthodox Theory - Shortcomings

- Implicit assumptions of NPV
  - Either the investment is reversible
  - Or, if irreversible, it is a « now or never decision »
- In reality
  - The ability to delay an irreversible investment can profoundly affect the decision to invest
    - ✓ The opportunity to invest = option (call) to buy assets
    - ✓ Making an irreversible investment = killing the option!
    - ✓ Lost option = opportunity cost that must be considered in the cost of the investment
    - ✓ Value of option ⇔ future net value is uncertain
  - New NPV rule should be...
    - ✓ Invest iff (value of unit of capital – costs) ≥ value of option alive

A note on irreversibility

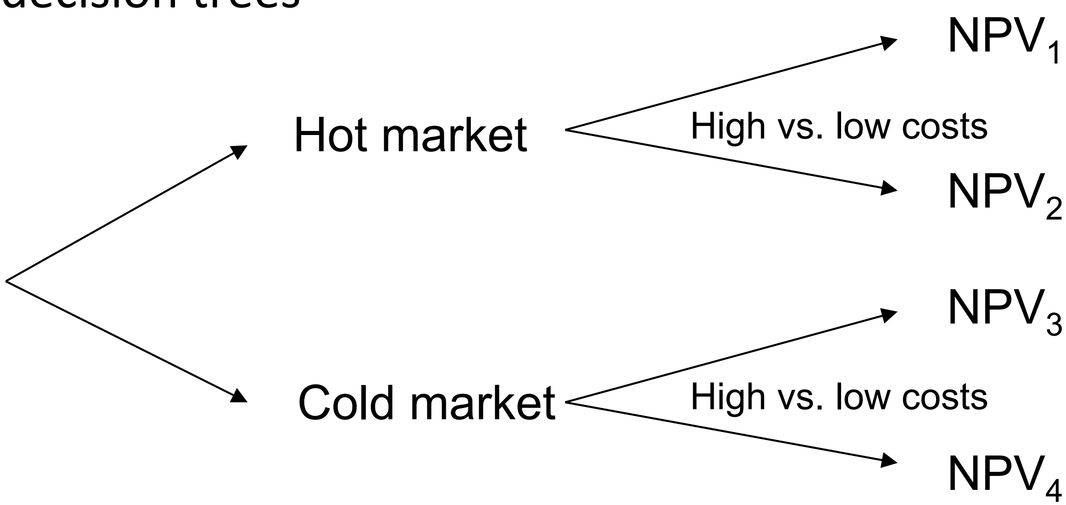
- Investment expenditures are (part. or entirely) sunk costs thereafter when
  - they are firm- or industry-specific
  - their quality is difficult to valuate for the counterpart (lemon)
  - government regulations or institutional arrangements are present
- Delaying Investments
  - Not always possible
    - ✓ Strategic considerations
  - Cost of delay
    - ✓ Risk of entry by competitors
    - ✓ Foregone cash-flows
    - ✓ But benefits of waiting for new information!
- How firms do obtain their options to invest in the first place?
  - Sometimes: patents, land, natural resources
  - Also: managerial resources, reputation, market position, scale, technological knowledge → build over time!
  - → Allow firms to undertake what others could not!
  - For most of firms, a substantial part of their market value is attributable to their options to invest and grow in the future, as opposed to the capital they already have in place.

The Orthodox Theory – Shortcomings (2)

- Opportunity cost is highly sensitive to uncertainty (perceived riskiness of future cash-flows)
- We need other valuation techniques to compute this
  - » Neoclassical investment theory fails in providing good models of investment behaviour (this could be a reason)
  - » Has led to too optimistic thoughts about interest-rate and tax effects in stimulating investment
  - » Evidenced hurdle rates = 3-4 times standard WACC
    - ✓ Firms wait for high hopes to invest
    - ✓ Firms may wait longly before accepting to disinvest

Why do we need something more sophisticated?

- Could we try still to use NPV and use probabilities on paths that the project may follow in the future?
  - » Like in decision trees



  - » In normal decision trees
    - ✓ Probabilities are attached to each branch
    - ✓ But the overall decision is actually made at origination, there is no decision left for the future!
  - » BUT…

Solution

- Standard option pricing theory for specific opp. costs
- Dynamic programming for sequential decisions

Examples

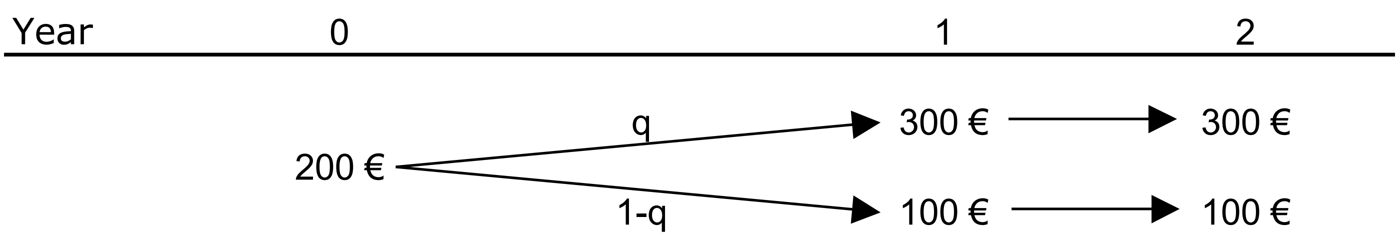
- Simple cases
  - » Option to wait
  - » Option to extend
  - » Option to liquidate
- New entry
- Determination of initial scale and future costly changes of scale
- Choice between solutions with varying degrees of flexibility
- Sequential completion of multi-stage projects
- Temporary shutdown and restart
- Permanent exit
- ...

from Wall Street to Main Street

- Until now
  - Relate future choices = options
  - ...that may embedded in the original project
  - Options = the value of flexibility
- In 1973, Black-Scholes & Merton provided the world with a breakthrough: Option pricing for financial underlying assets
- Some years later, Merton will propose to use the option concept for real-world decisions on real-world assets → Real Options theory was born
- Using options theory
  - Allows us to price simple economic options embedded into projects
  - Allows us to provide an abstraction for strategic decisions (may not necessarily require "valuation")
- For the valuation of complex « options »
  - Monte Carlo simulations
  - Binomial/Trinomial trees
  - Dynamic programming for sequential decisions

Price uncertainty over two periods

- Endowments
  - Decision: invest in a widget factory
  - Irreversible
  - Factory can be built instantly at I , produces 1 widget per year forever with 0 operating cost
  - Price is at 200€ but will change next year and remain then at new price forever



  - Future cash-flows are discounted at riskfree rate: 10%

Price uncertainty over two periods(2)

- Invest now?
  - » NPV with I=1600€ and q=0.5

$$NPV = -1600 + \sum_{t=0}^{\infty} \frac{200}{(1+0.1)^t} = -1600 + 200 + \frac{200}{0.1} = -1600 + 2200 = 600€$$

  - » We wait one year and invest if widget price goes up

$$NPV = 0.5\left[-\frac{1600}{1.1} + \sum_{t=1}^{\infty} \frac{300}{(1+0.1)^t}\right] = 0.5\left[-\frac{1600}{1.1} + \frac{3300}{1.1}\right] = \frac{850}{1.1} = 773€$$

  - » Choice depends on if we can wait or not one year (=do we have the option?)
    - ✓ No option = no opportunity cost in killing such an option
    - ✓ We would invest today if tomorrow we could disinvest and recover 1600€ would the widget price fall
    - ✓ So, need (irreversibility + ability to invest in future)
    - ✓ Irreversibility is important unless time to delay is short or costs of delaying are high
  - » Value of flexibility = 773€ - 600€ = 173€

Price uncertainty over two periods(3)

- We should therefore be willing to pay 173€ more for an investment opportunity that allows us to wait one year
- How high could be I to accept the « flexible » project?
  - » Solving for

$$NPV = 0.5\left[-\frac{I^*}{1.1}+\sum_{t=1}^{\infty}\frac{300}{(1+0.1)^t}\right] = 600€$$

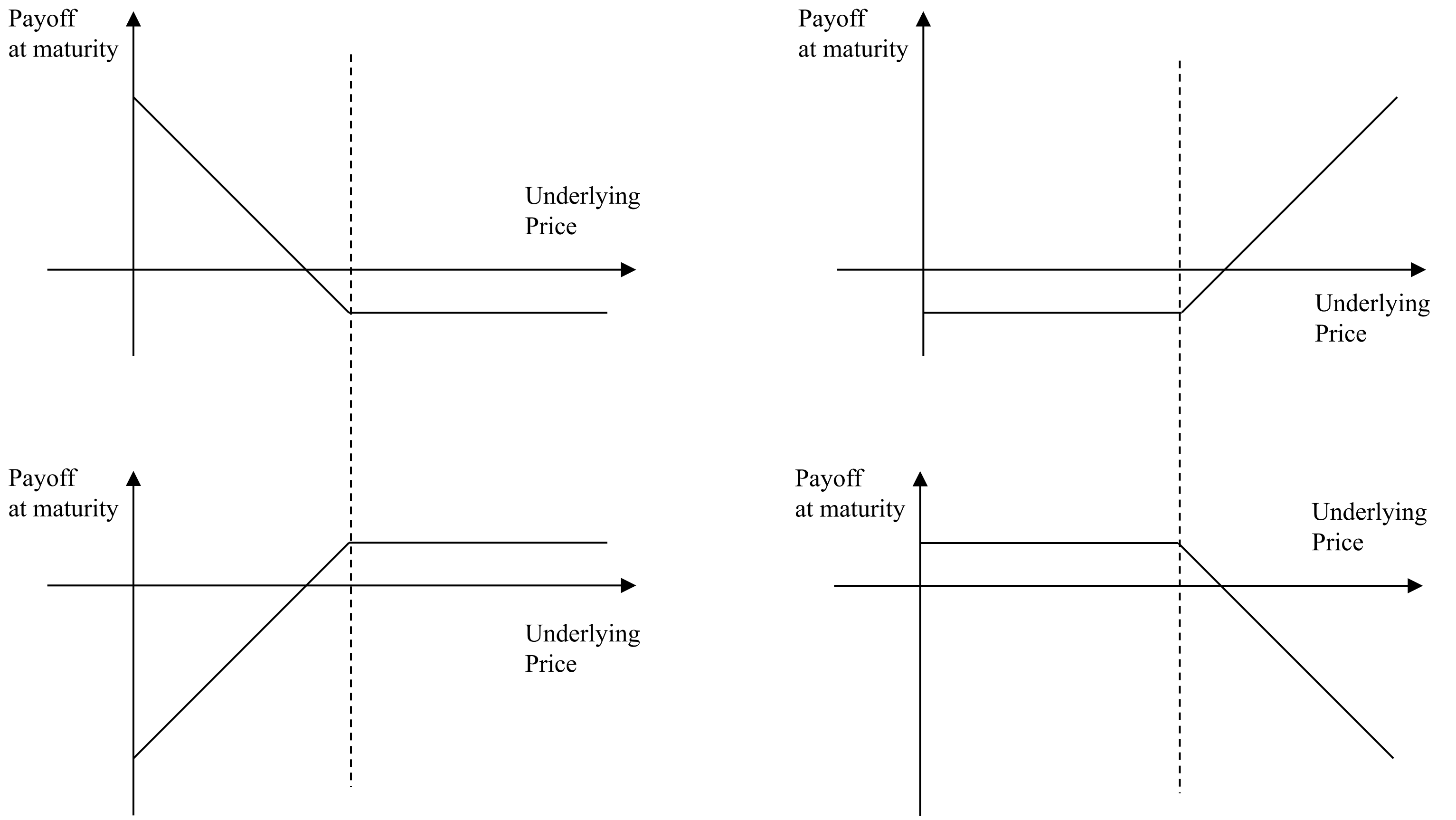
  - » Gives: $I^* = 1980€$

Option Theory

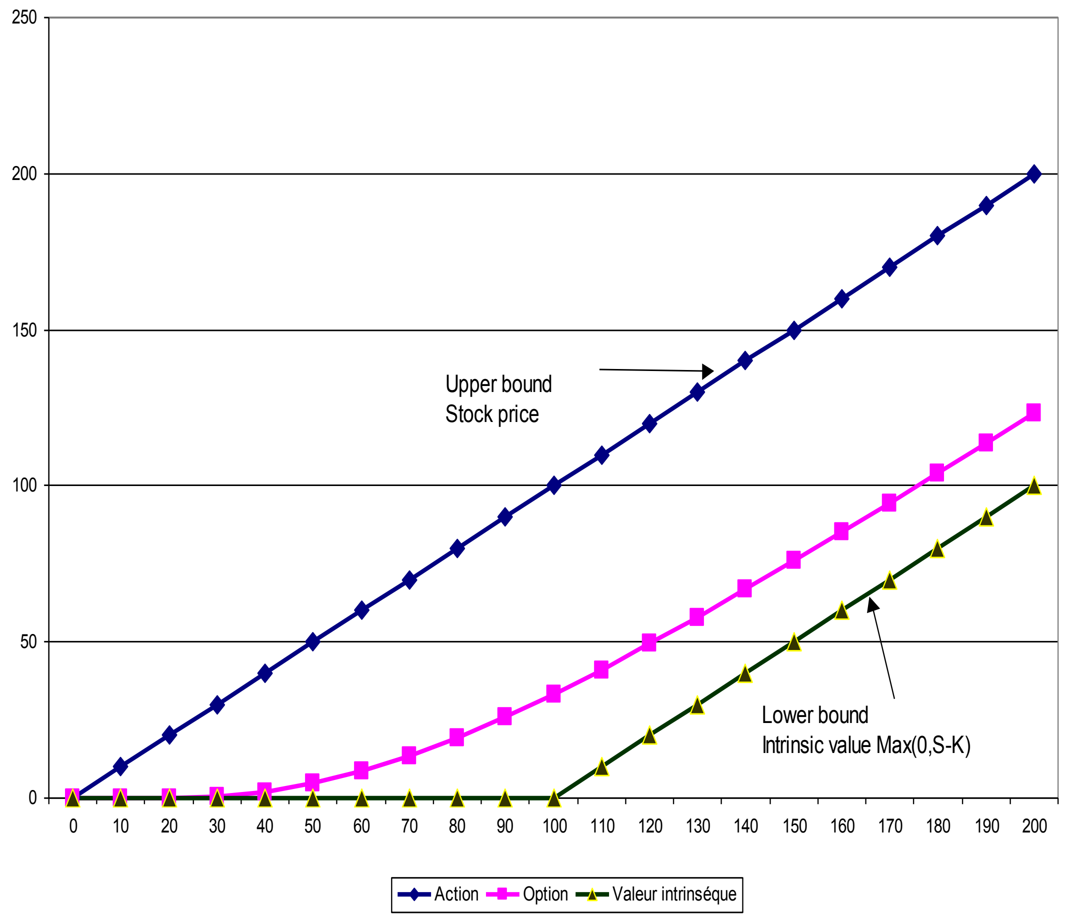
- Standard forms
  - Call: right to buy tomorrow something at a today's fixed price
    - Buyer's payoff at maturity: $Max\left(S_T - K, 0\right) = \left(S_T - K\right)^+$
    - Value today: $e^{-rT} \mathrm{E}_0^Q \left(S_T - K\right)^+$
  - Put: right to sell tomorrow something at a today's fixed price
    - Buyer's payoff at maturity: $Max\left(K - S_T, 0\right) = \left(K - S_T\right)^+$
    - Value today: $e^{-rT} \mathrm{E}_0^Q \left(K - S_T\right)^+$

Option Theory (2)

- European Options (net) payoff profiles at maturity

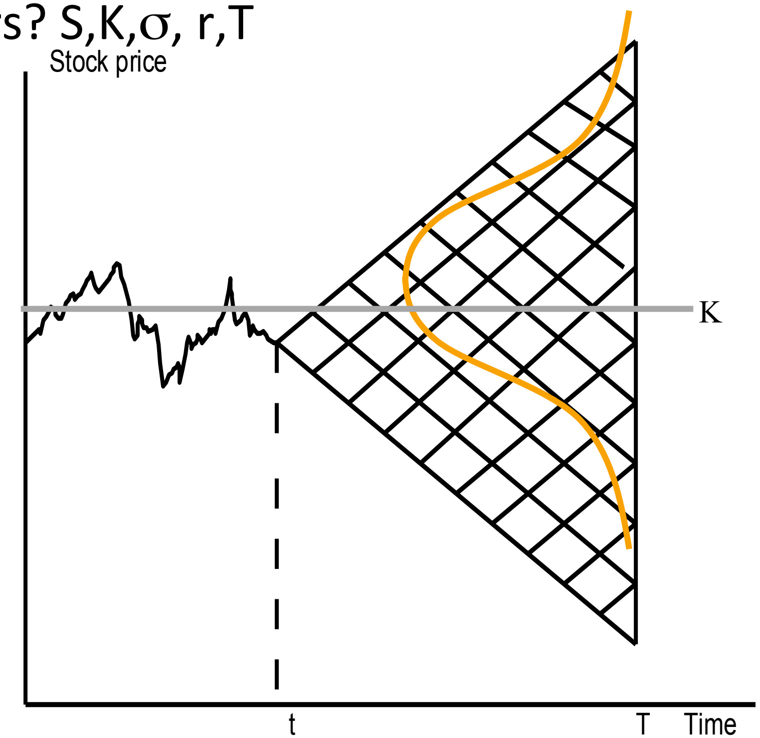


Option Theory(3)



Option Theory(4)

- Standard forms
  - » Features: American/European
  - » Pricing: Binomial/Black&Scholes/Simulations/Finite differences...
  - » Parameters? S,K,σ, r,T



Black-Scholes model

- Call price $C = S_0 e^{-yT} N(d_1) - Ke^{-rT} N(d_2)$

$$d_1 = \frac{\ln\left(\frac{Se^{-qT}}{Ke^{-rT}}\right)}{\sigma\sqrt{T}} + 0.5\sigma\sqrt{T} \qquad d_2 = d_1 - \sigma\sqrt{T-t}$$

- Put price $P = Ke^{-rT} N(-d_2) - Se^{-qT} N(-d_1)$

- Parameters
  - » S =current value of underlying
  - » K =strike price
  - » T =time-to-maturity
  - » σ =standard deviation of ΔS/S
  - » r =riskfree rate
  - » y =dividend rate=opportunity cost of waiting, etc...
  - » N(z) =cumulative standard normal probability density from -∞ to z

Or…use the binomial model

The Put-Call parity

$$Se^{-qT} + P = C + Ke^{-rT}$$

The option to wait

- Principles:
  - A today's NPV<0 project may become positive in the future
  - Not investing today in what can help us to have this opportunity in the future is killing this option
    - ✓ Ex: cost of a patent
- Complete example: A pharmaceutical project
  - A pharmaceutical company is being proposed a patent obtained by an entrepreneur for a new medicine to treat ulcers. The patent is valid during 20 years. The medicine is very expensive to produce and the market is tight. It requires an investment of 500 million € and the market is estimated to return 350 million €.
  - Other data : σ 2 = 0.05, r = 7 %
  - Solution
    - ✓ S = 350 mios, K = 500 mios, t = 20, y = 1/20 = 5 %
    - ✓ d1 = 0.5433, N(d1) = 0.7065
    - ✓ d2 = -0.4567, N(d2) = 0.3240
  - C = 51.03 million €

The option to extend

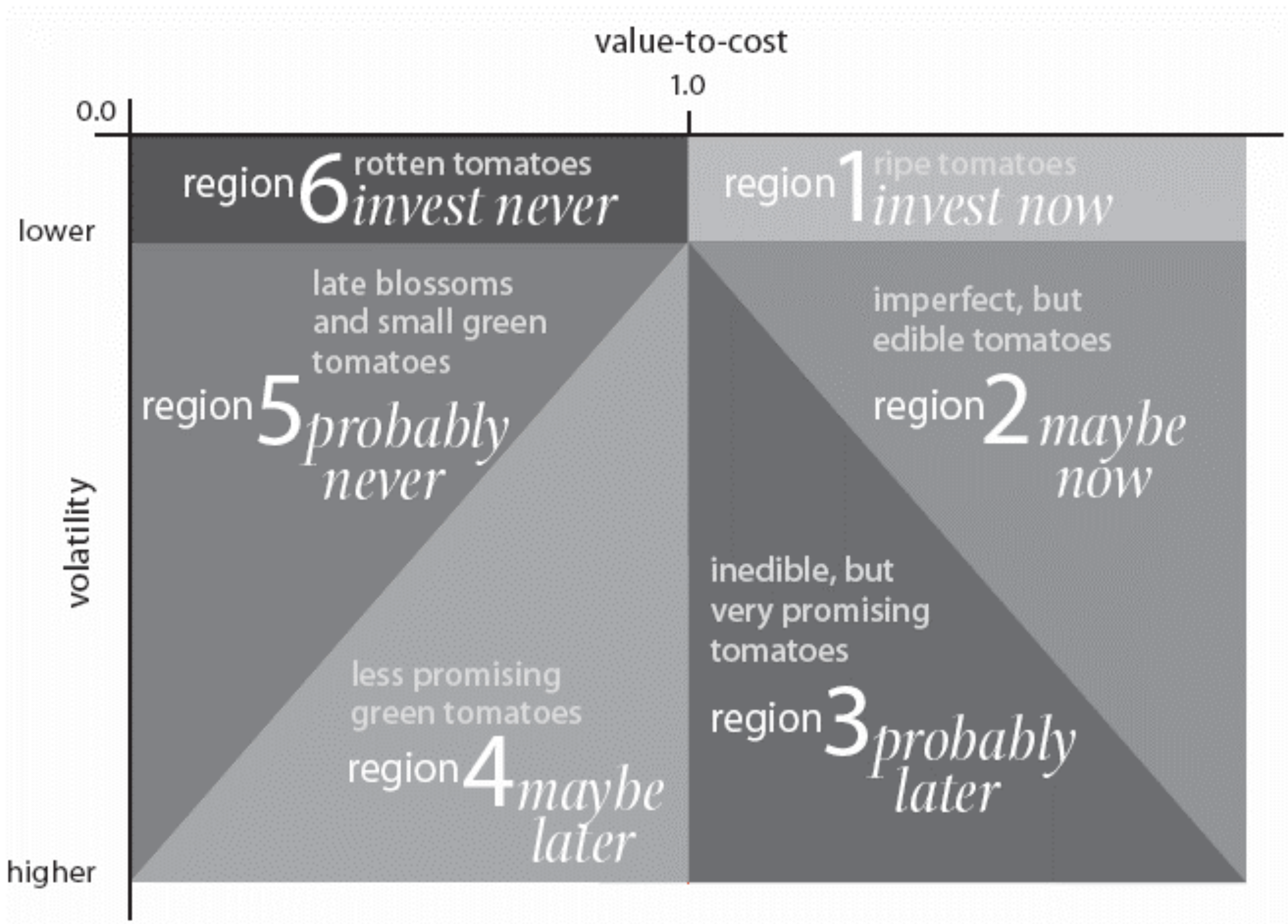
- Principles:
  - An extra-investment today conveys an option to extend our currently desired activity
  - Not investing today in what can help us to have this opportunity in the future is killing this option
- Complete example: A pharmaceutical project
  - Home Depot is considering the opening of a store in Brussels. Installation costs are up to 100 million € and the estimated present value of forecasted cash-flows is 80 million €.
  - By opening this store, Home Depot acquires the option to extend the selling surface in Brussels over the next 5 years. The costs for the extension amount to 200 million €. The extension will not be undertaken is net profits do not reach 200 million €. The current cash-flow expectation is only 150 million €. The uncertainty in the retail industry is quite high and the variance is estimated at 0.08. The annual riskfree rate is 6%. Should Home Depot invest in the store in the first place?
  - Solution
    - ✓ S = 150, K = 200, $\sigma 2$ = 0.08, t = 5, r = 6 %
    - ✓ d1 = 0.3357, N(d1) = 0.6315
    - ✓ d 2 = -0.2968, N(d2) = 0.3833
  - C = 37.92 million € > 20 million €

The option to abandon

- Principles:
  - » A project could convey the right to disinvest when desired at a predetermined level
  - » Not considering this option could worsen our expectation of final cash-flows for the project.
- Complete example:
  - » Assume you may undertake an investment for a 10-year project requiring an initial outlay of 100 million € in a real-estate company. Expected cash-flows have been estimated to be 110 million €. Assume also that you may quit the project at any time selling back your share for 50 million €.
  - » The variance of PV(cash flows) is 0.06.
  - » The riskfree rate is 7%.
  - » Solution
    - ✓ S = 110, K = 50, $\sigma 2$ = 0.06, t = 10, y = 1/10, r = 7 %
    - ✓ C = 19.41 million €
    - ✓ From the put-call parity: P = 3.78 million €
  - » NPV = 10 + 3.78 = 13.78 million €

For Strategic decisions

- (see excel file TN on Real Options)



Source: Luerhmann, Harvard Business School

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