Note 3: Real Options

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Session: Real Options

Learning Objectives

1. What is a real option?
   - When is there a real option embedded in a decision or an asset?
2. Under what conditions are real options valuable?
3. How can the value be estimated using option pricing model?

An investment opportunity?

- A young start up has come up with a new technology to organize images. The cost of implementing this technology is $ 3 billion while PV(FCF)=$ 2.5 billion. Should they implement the technology?
  - Yes
  - No
- Now assume, you work for an established tech firm like Google, Apple, Microsoft etc. You are evaluating purchasing this technology which is patented for 10 years. Should you be willing to pay for it?
  - Yes
  - No
- Impact of uncertainty and life of patent?

Real options
The Key Idea

NPV treats each investment as a **now or never** decisions. But investments are flexible. For instance, you can scale up or scale down based on new information.

- **"Now or never"** does not consider additional choices to structure the investment favorably
- Risk/uncertainty associated with large IT investments
- Does not consider options, which are choices to take some actions in the future based upon certain outcomes
- Real Options Analysis - Firm has the right but not the obligation to acquire IT assets
  - Active NPV = Passive NPV + Value of managerial flexibility (value of real option)

Real options
The Key Idea

- 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)
- Real option implies that NPV of any investment=Passive NPV(static DCF) + NPV(Flexibility)
  - But is flexibility always valuable?

Features of Decisions: When are real options valuable

- Partially or completely irreversible
- Uncertainty about future
- Choice over actions or timing
- Exclusivity / Competition

How should a firm facing uncertainty over future market conditions decide (e.g., to invest)?

- Is Passive NPV enough?

Irreversiblity

Uncertainty

Timing


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FISH
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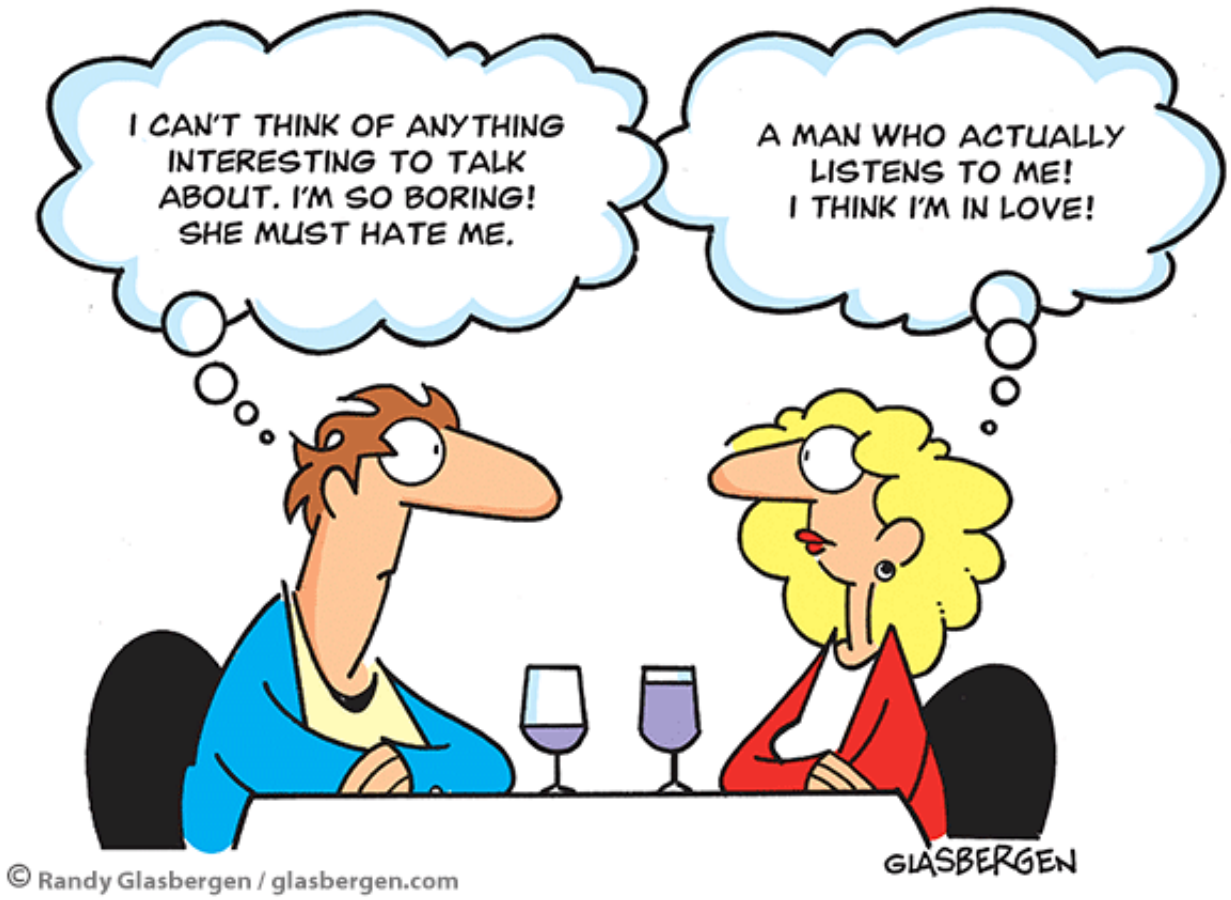
"Why are you so afraid to commit? Do you really think you're going to meet someone better than me?"

Dating


I CAN'T THINK OF ANYTHING INTERESTING TO TALK ABOUT. I'M SO BORING! SHE MUST HATE ME.
A MAN WHO ACTUALLY LISTENS TO ME! I THINK I'M IN LOVE!
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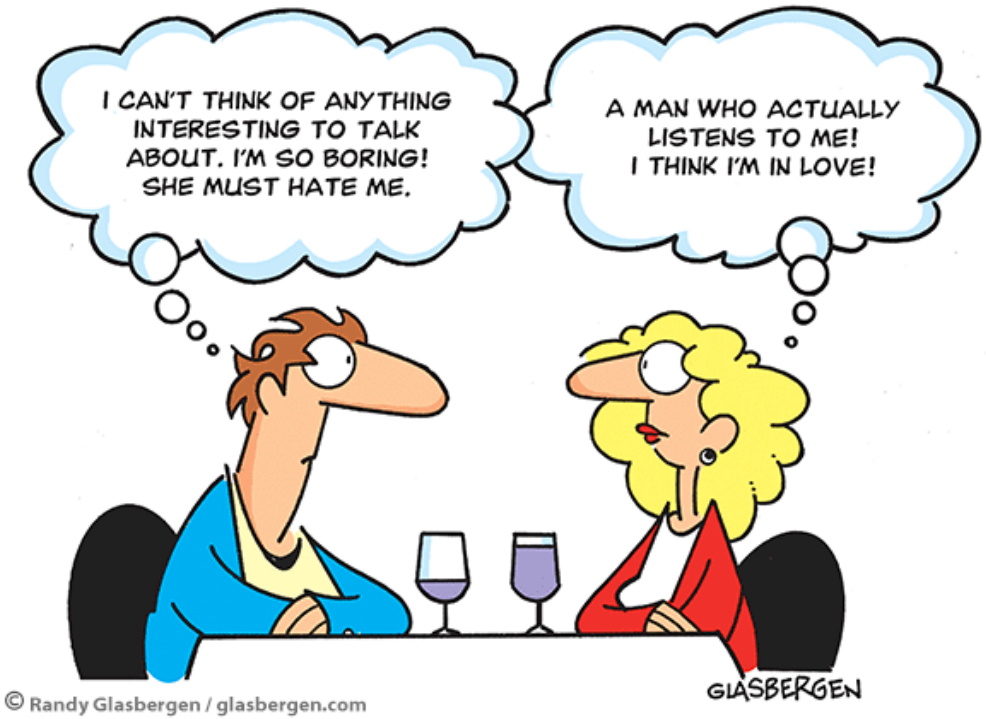
Dating



Market research?

- Gather more information
- Option to delay!

But Market research is costly!!!!!

"For a girl who said she was 'free for the evening'

you're costing me a fortune."

Exclusive Rights / Competition

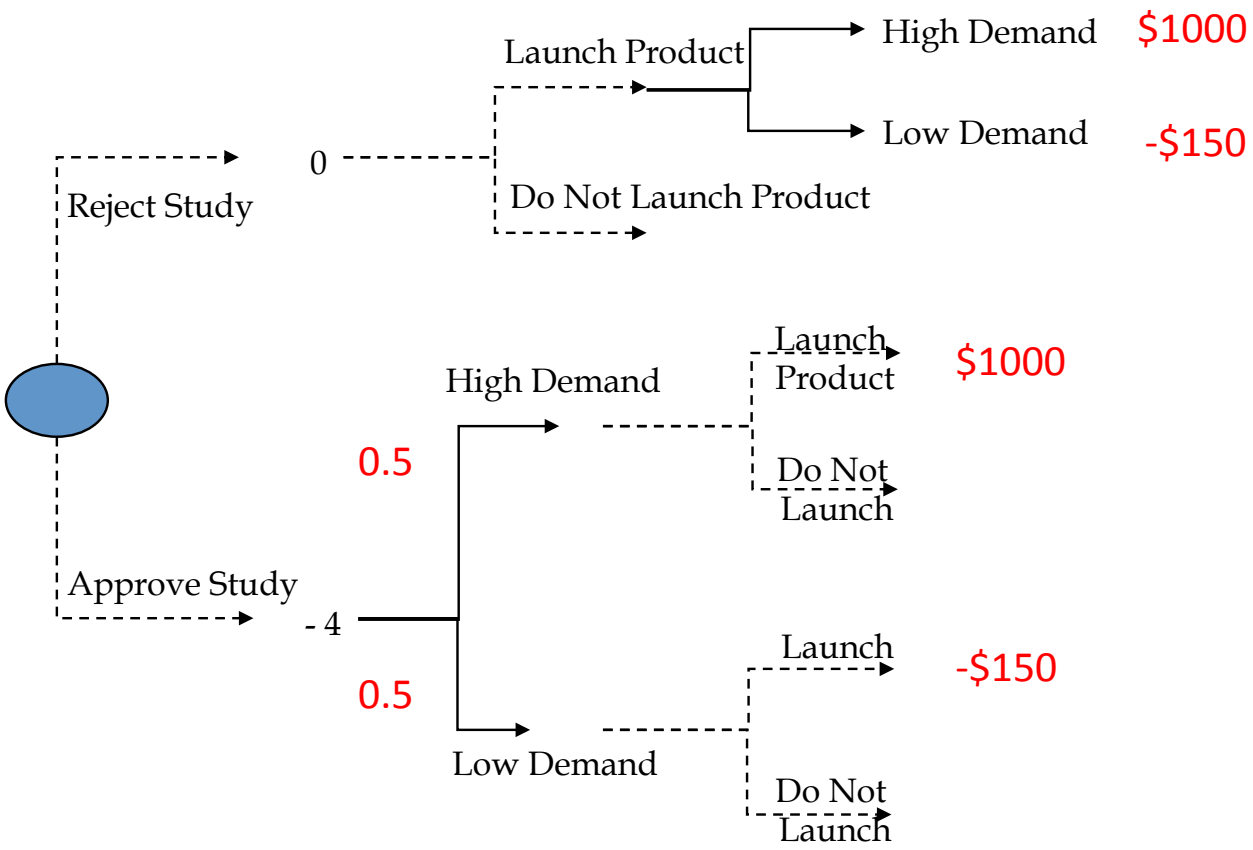
"Yes, I did agree to a double date. However, taking two women out at the same time isn't what I expected!"

Evaluating Market Research - Example

You are the CFO of Kellogs and have been approached by the marketing director for approval for running a market research for XYZ breakfast cereal. The study will cost $4 Million and will provide valuable information on market potential based on which you can decide whether or not to launch the product.

- How will you evaluate this expenditure proposal?
- What are the cash flows relevant for evaluating it?

Mapping the options (AKA Decision Tree Method)



Comparing Alternatives

- Launch Without Study (NPV approach)
  - $V_{\sout{study}} = 0.5 * 1000 + 0.5 * (-150) = 425$
- Do the study and launch if demand is high
  - $V_{study} = -4 + 0.5 * (1000) = 496$
- Conclusion: Should do the study and launch if demand is high.
- What is the value of option to invest after extra information?

Value of Real Option

- Market research provides information that helps take future decisions
  - If the demand is high → Launch project
  - If the demand is low → Abandon project
- The option to change course in future is called a "Real Option".
- Doing market research is equivalent to buying a "Real Option".
- Real options are valuable if outcomes are variable (Uncertain)
  - In this case demand in good and bad scenarios is variable.

Real Options Bottom line: Flexibility

- Investments are not one time decisions
- They are a series of decisions
  - Managers are paid to monitor project progress and take actions
    - Projects are expanded/fast tracked if things go well.
    - Projects are scaled down/abandoned if things turn out bad.
  - Google wave, google buzz, HP touchpad
- "Flexibility" is the ability to change courses mid-way
- Standard DCF is static - NPV estimates Ignore the value of flexibility
- Real options - NPV estimates incorporate the value of the flexibility.

Flexibility: Valuable Option

- Sometimes such flexibility is in-built in projects
  - E.g. Ships which can be scrapped in case of low freight rates
- Sometimes you can buy flexibility
  - Doing market research, R&D
- Flexibility can be thought of as the “Option" to take a future action depending on market conditions.
- Flexibility is valuable.
- We need to take its value into account when valuing projects/assets.

Examples

- Common examples of real options (from "Real Options" by Lenos Trigeorgis):
  - Option to defer: company holds a lease on or an option to buy valuable land. Typical in oil extraction, mining and real-estate industries.
  - Staged investment: each stage may be viewed as an option on the subsequent stages. Typical in start-up, R&D-intensive and energy-generating industries.
  - Option to alter operating scale: expand, contract, shutdown and restart. Typical in consumer goods, mining and fashion apparel industries.
  - Option to abandon: sell all capital assets. Typical in capital-intensive industries.
  - Option to switch: change output mix or produce same output using different inputs. Typical in toy industries, automobile.
  - Even football clubs have real options: whether to hire players from school, when to fire them, when to promote them to second team and full team.

Summary: Real Options are valuable

- Why are these options valuable?
  - Help avoid negative outcomes
    - The option available with an oil company to stop producing oil from an oil field if prices fall too much.
  - Help take advantage of positive outcomes
    - Market research may enable a firm to fast track the introduction of the new product.
- When are the options most valuable?
  - When there is greater uncertainty.
- Learning and adaptive behavior are key to real options.
- Ignoring options will lead to incorrect valuation and hence wrong decisions.

Two Common Methods

You can analyze/value real options using at least two methods

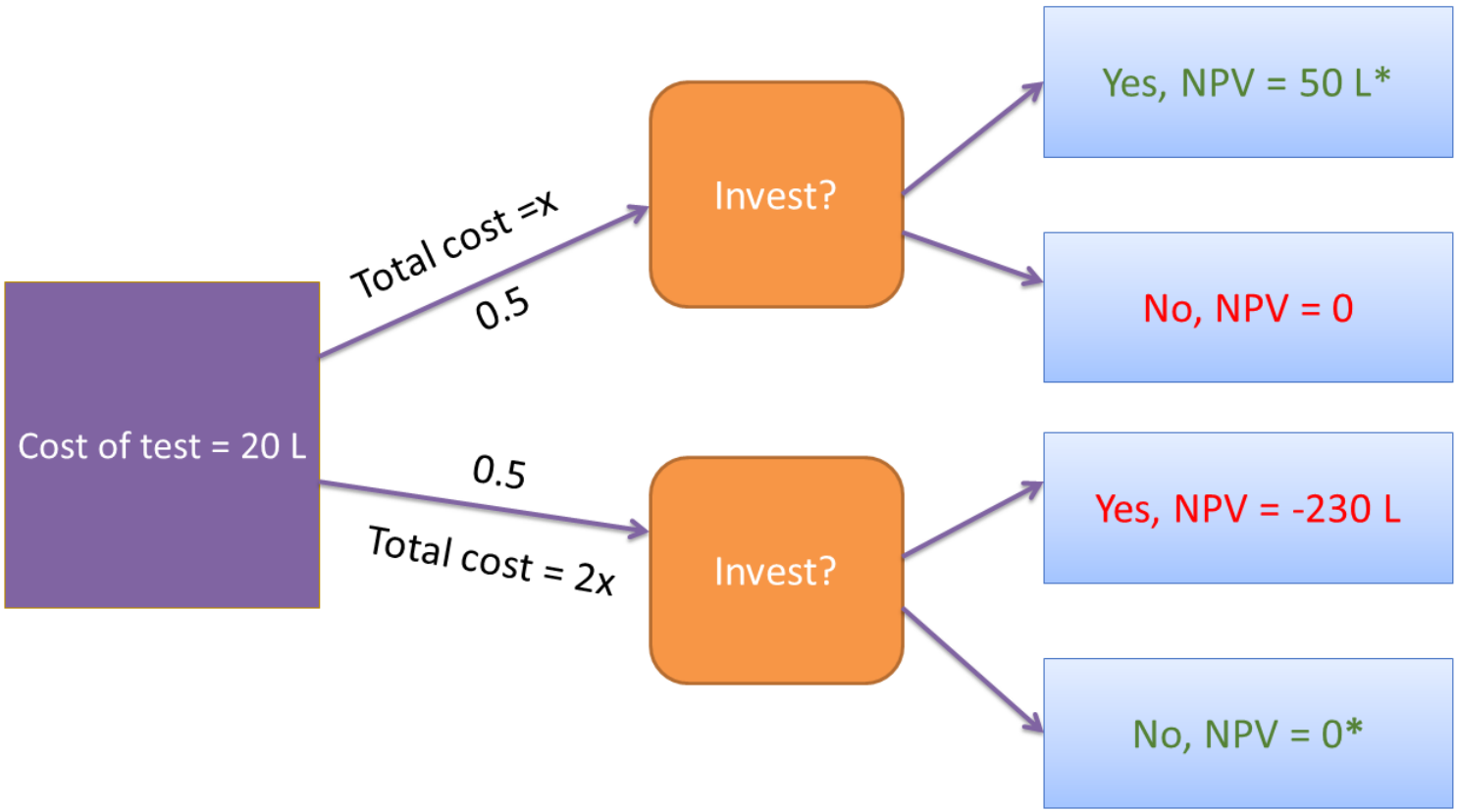
1. When underlying uncertain variable can take on many values (Black-Scholes approach)
   - Black-Scholes method - continuous time
   - Common method used in real option, using NPV_q and $\sigma\sqrt{t}$
   - BS Value=NPV(Static DCF)+NPV(Flexibility)
2. When underlying uncertain variable can take on few discrete values
   - Decision tree: Active NPV (with option) = NPV Static(without option)+NPV (Flexibility)

An option's view of the Analytics platform investment

- What if one of the risky elements in this project, the life-cycle cost (i.e., initial + annual costs), doubled?
- For ease of understanding sensitivity analysis, let us put all cash flows into three categories (all in present value terms):
  1. Initial cost = 58 lakhs
  2. PV(Benefits) = 330 lakhs
  3. PV(Annual costs) = 222 lakhs
- Hence, we get
- PV of benefits = ₹330 lakhs
- PV of costs = ₹280 lakhs
- Suppose there is a 50% chance of the costs being double, that is, ₹560 lakhs
- "Passive" NPV $= 330 - (0.5 \times 280 + 0.5 \times 560) = -90$ lakhs $\Leftarrow$ Reject the project

"Test"

- Let's say that a test or a pilot helps determine if the cost will be x or 2x
- The cost of this test phase is ₹20 lakhs



Active NPV

- Active NPV $= -20$ lakhs $+ 0.5 \times 50$ lakhs $+ 0.5 \times 0 =$ ₹5 lakhs $\Rightarrow$ once we consider the test phase, we accept the project, that is,
  - We decide to run the test today
  - If the test reveals that cost will be ₹280 lakhs, then we will go ahead with the entire project
  - If the test reveals that the cost will be ₹560 lakhs, then we will reject the entire project
- Being able to avoid the negative NPV when the cost is found to be high helps make the project NPV positive

Value of the flexibility

- Value of flexibility = Active NPV – Passive NPV = 5 lakhs - (-90 lakhs) = ₹95 lakhs
- Since these flexibilities help avoid negative outcomes, their value is never negative
- IMPORTANT: This flexibility is worthless if it DOES NOT resolve uncertainty
  - In our example, the test helps resolve the uncertainty as to whether the cost will be low (₹280 lakhs) or high (₹560 lakhs)

Wrap up

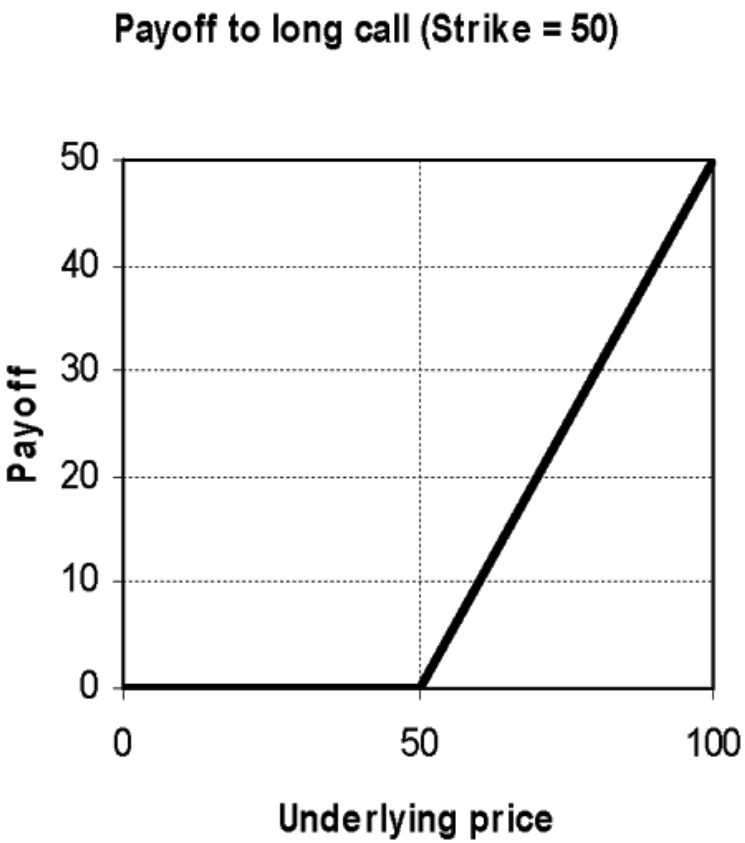
Financial Options

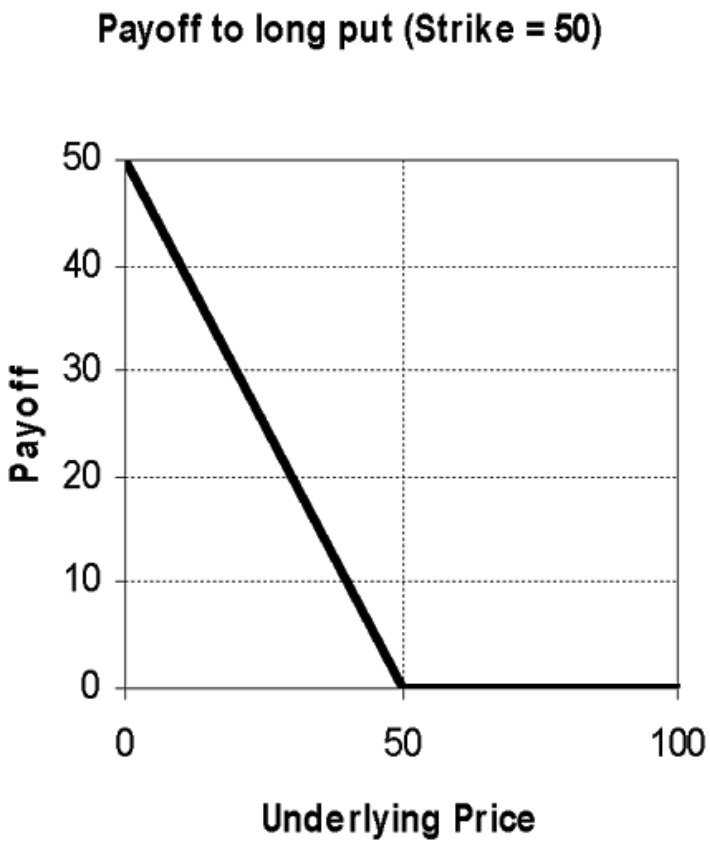
- Option: It gives the holder the right to trade the underlying asset at a stated price (called the exercise or strike price).
  - Right to buy: call.
  - Right to sell: put.
- Can be viewed as insurance contracts.
- Two styles of options:
  - European - can be exercised only on expiration date.
  - American - more flexible; can be exercised any time prior to or on expiration date.

Option payoffs

- Payoffs:
  - Call: $\max(S_T - K, 0)$.
  - Put: $\max(K - S_T, 0)$.

Option payoff diagrams





Black-Scholes-Merton model

- With infinite subperiods, then we get the Black-Scholes-Merton model.

$$\begin{aligned} \text{European call premium} &= S_0 N(d_1) - K e^{-rT} N(d_2) \\ \text{European put premium} &= K e^{-rT} N(-d_2) - S_0 e^{N}(-d_1) \end{aligned}$$

$$d_1 = \frac{\ln\left(\frac{S_0}{K}\right) + \left(r + \frac{1}{2}\sigma^2\right) T}{\sigma\sqrt{T}}$$

$$d_2 = \frac{\ln\left(\frac{S_0}{K}\right) + \left(r - \frac{1}{2}\sigma^2\right) T}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T}$$

$$PV(K) = Ke^{-rt} \approx \frac{K}{(1+r)^t}$$

- $N(x)$ is the area under a standard Normal distribution to the left of x,
- S_0 is the current stock price,
- K is the strike (or exercise) price of the option,
- T is the time to expiration of the option in years,
- σ is the standard deviation of annual asset returns, and
- r is the risk-free rate of interest.

Call Option Formula - Intuitive Explanation

- SN(d_1) is the present value of the expiration date stock price conditional on the stock price exceeding K.
- Similarly, Ke^{-rt}, is the presented value of the strike price K. This is only paid if you exercise the option that is when S(T)>K. N(d_2) is the probability that S(T)>K at the expiration date T.
- So, now this looks very similar to a standard valuation. The Black-Scholes price is effectively the present value of expected cash flows from holding the option.

Four kinds of real options

Real option	Equivalent financial option
Option to expand	Call Option
Option to delay/time investment	Call Option
Option to abandon	Put Option
Option to alter production	Combination of call and put

Steps for Valuing Investments using Black-Scholes approach

- Identify the option type - e.g., call, put, etc.
- Match characteristics to option formula, especially
  - Underlying asset, exercise price, time to maturity, time value of money
  - Model the uncertainties (riskiness of underlying operating assets) - Monte Carlo, Historical Data, Comparables Data
- Value the real option
  - BS Value=True NPV(Investment)=NPV(DCF)+NPV(Flexibility)
- Example: for a call option,

Project: Investment Decision Delay	Variable	Call option
Expenditures required to acquire the assets	K	Exercise price
Value of the operating assets to be acquired	S	Stock price
Length of time decision may be deferred	t	Time to expiration
Riskiness of the value of the underlying operating assets	σ^2	Variance of returns on stock
Time value of money	r	Risk-free rate of return

Example using B-S

FedEx - Option to Expand

In 2000 FedEx placed an order for 10 Airbus A380 super-jumbo transport planes for delivery in 2008-2011

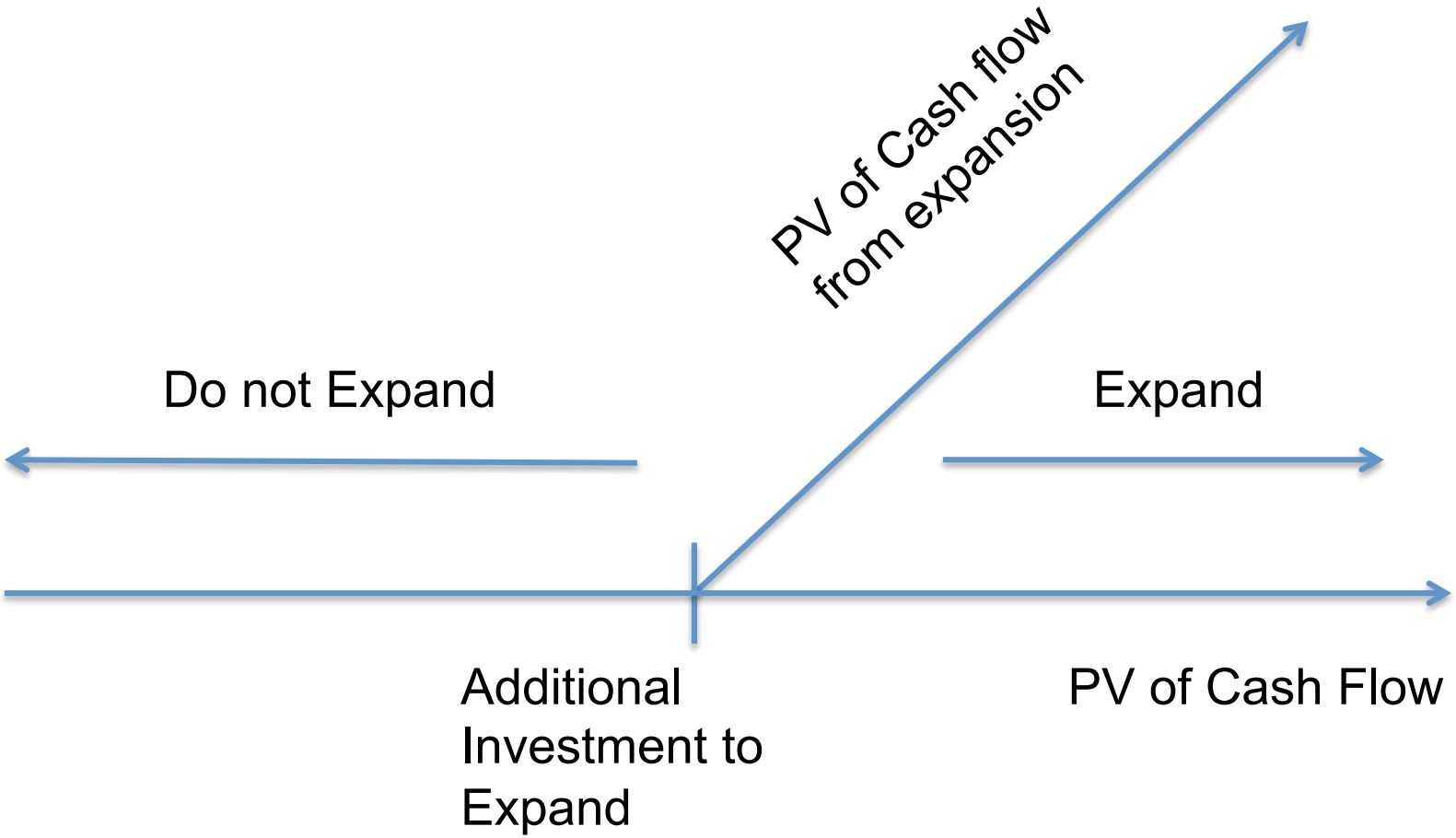
- A large investment - $1000 Million
- Cash flows will be realized much later in the future - Increases uncertainty - PV(Cash Flow) = $750 Million
- What happens if FedEx buys planes and the demand is low?

Airbus realizes this and provides an option for FedEx to place a contingent order. FedEx secured a place in Airbus production line by acquiring options to buy a "substantial number" of additional aircraft at a predetermined price at a future date.

- The option does not commit FedEx to expand but gives it the flexibility to do so.

Example using B-S - Payoff

FedEx - Option to Expand



Example using B-S: Dilemma

FedEx - Option to Expand

- FedEx can payoff $1000 million in dividend to its shareholders, or
- Set aside the capital for purchasing these planes.
- What Should FedEx do?

Example using B-S: Option Value

FedEx - Option to Expand

- Payoff structure of Airbus' offer: Call option
- Value of the Underlying Asset (S) = PV of Cash Flows =$ 750 Million
- Strike Price (K) = Cost of Expansion = $ 1000 Million
- We estimate the standard deviation in the estimate of the project value by using the annualized standard deviation in demand for courier services. σ = 34.25%, risk-free rate r_f = 6.5%
- Time to expiration = Period for which expansion option applies = 5 years

Call Value= $ 234 Million

Example using B-S: Why It Works

FedEx - Option to Expand

- Standard NPV Rule: \$750- \$1000=-\$250 Million.
  - Project is -ve NPV → Do not invest → Pay Dividends.
- But the option to expand later: \$ 234 Million.
  - This is the PV of expected cash-flow from buying the planes 5 years from now.
- What is -ve NPV now can become +ve NPV in future.
- The option to expand later is valuable.
  - Do not pay dividends → Set aside capital for flexibility to purchase planes later.
- **What does this example tell you about valuing companies with negative cash flows?**

Market Values are More Reliable

Example - Cisco

- Sell: Networking supplies
- Expansion options
  - Scale-up → Supply network equipment for Internet connectivity
  - Scope-up options → Supplies businesses and individuals
  - Option to enter into new product markets.
    - Integrating voice, video and data in their network

Market Values are More Reliable

Example - Cisco DCF Valuation

Year	EPS	Net Income (billions)
2001	\$0.720	\$ 5.054
2002	0.945	6.669
2003	1.241	8.775
2004	1.630	11.513
2005	2.140	15.093

- Estimated Cost of equity=13.7%, Assume growth rate of 10%
- Terminal Value$_{2005}$ = $\frac{\$15.093(1+0.10)}{(0.137-0.1)}$ = \$448.800 billions
- DCF$_{2000}$=PV(Net Income)+PV(Terminal Value$_{2005}$)≈\$270 billions

Market Values are More Reliable

Example - Cisco DCF vs Market Capitalization

- DCF = \$270 billion vs. Market Value$_{2000}$= \$445.1 billion
  - Difference of \$178.5 billion
- Sensitivity Analysis
  - Vary constant growth rate of 10% to 11%. DCF=\$352 billion
  - Market Value - DCF value=\$91.1 billion
- Not considering the growth/expansion option leads to gross undervaluation.
- Standard DCF may ignore option value. Market capitalization need not.
- What if DCF assumptions included options?

Summary - Black-Scholes

- Black- Scholes is a powerful way to value options, especially if
  - the problem can be converted into B-S ingredients
  - market-based information are available
- However, it is often not intuitive. A black box!
- We can use alternatives methods - Decision trees

Summary - Black-Scholes
Pitfalls

- Inserting wrong values.
  - Volatility is a key driver of option value, the higher it is the higher the value of the option. Is your volatility estimate correct?
- Using Real options when you should not!
  - Exclusive rights?

Some Useful Applications

- Patents - Expansion/Growth option
- Young start ups with -ve cash flows - Expansion/Growth Option
- Decision to enter new markets - geographical or product markets.
  - Emerging market investments as expansion options.
    - Cash flows may be negative now but can quickly capture markets as economy grows - McDonalds
- Natural Resources - Timing
- Ability to time investments based on exclusivity.
  - Microsoft - exclusivity rights over MS office based on initial success and control over Windows platform. Remember Lotus smart suite.
  - I-phone success based on exclusive relationship with "cool" clientÃÍle (Brand consciousness).
  - Exclusivity can be achieved by proprietary technology (patents), proprietary data (Facebook?), brand image, key talent (Yahoo aqui-hiring).

Summary: Valuing firm with Patents/New Technology

- The value of a firm with non-commercialized patents/technology can be derived using the option pricing model.
  - Value of Firm = Value of commercial products (using DCF value) + Value of existing patents (using option pricing) + (Value of New patents that will be obtained in the future - Cost of obtaining these patents)
- If we use this approach, we should be careful not to double count
  - Do not assume high growth rate in cash flows (in the DCF valuation).

Food For Thought

Are options useful for valuing smartphone apps?

- Why or Why not?
  - Exclusivity - Swiggy, Foodpanda Whizzle
- How can exclusivity be achieved?
  - Whatsapp? - Hooking consumers! Early entry
  - Marriots entry in China, Mc Donalds in India
  - And of course proprietary and patented technology?
  - Can this always ward off competition?
  - HD-DVD vs Blue Ray, MP3 vs Attrac format?

Takeaways

Food For Thought

- Assume you have an investment opportunity to start producing a diabetes drug. The PV(FCF)=$ 2 bllion. Production costs are $1.5 Billion. Should you start production?
  - Yes
  - No
- Suppose volatility is 25%. Risk-free rate is 5%.
- What if you could defer the investment for 3 years. What is the value of this investment opportunity now?
  - sN(d1)-PV(K)N(d2)=1.78-1.0154=$764 Millions
  - What does this mean?
- Option to delay is valuable: The NPV of waiting and investing 3 years from now is better than investing today.
- Any caveats?

Takeaways

- Real options are valuable and cannot be ignored.
- Factoring them could affect the decision to accept/reject the project.
- Real options allow a much more precise estimate of investment decisions on shareholder value.
- The value of real options is greatest when
  - there is greater uncertainty.
  - you have exclusive rights over the investment opportunity - patents, un-exploited mines, etc
- Very useful in valuing high growth companies - high tech firms - pharma, mines, oil fields, the decision to enter emerging markets, young firms with negative cash flows.
- Market-based information is more reliable and hence preferable in determining methodology choice.