Introduction to Real Options
using @RISK and PrecisionTree

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Real Options

- Real options capture the value of managerial flexibility to adapt decisions in response to unexpected market developments.
- The real options method applies financial options theory to quantify the value of management flexibility in a world of uncertainty.
- A **real option** itself, is the right - but not the obligation - to undertake some business decision; typically the option to make, or abandon, a capital investment.

real-options.org

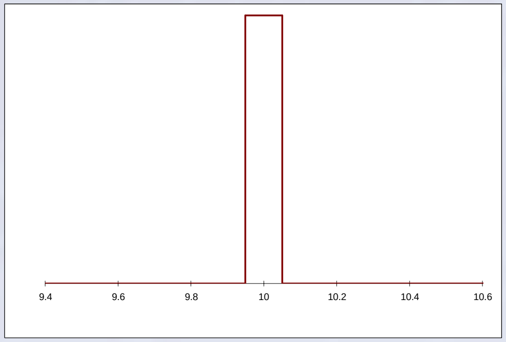
Comments

- With ROA, uncertainty inherent in investment projects is accounted for by risk-adjusting probabilities. Cash flows can then be discounted at the **risk-free** rate. In DCF uncertainty is accounted for by adjusting the discount rate, using e.g. the cost of capital) or the cash flows (using certainty equivalents). These methods do not properly account for changes in risk over a project's lifecycle and fail to appropriately adapt the risk adjustment
- Real options value requires
  - The ***presence of risk*** (variability) in the (initial) outcome possibilities
  - ***The ability to respond to these outcomes***
- If the model had been a business plan for 5 years, it might not be best to close the business if it were unprofitable in year 1
  - Where “optimal exercise” is an important feature of the problem, tree-based approaches are often necessary
  - RO analysis requires a mix of PT and/or @RISK, according to circumstances

RO classification (?)

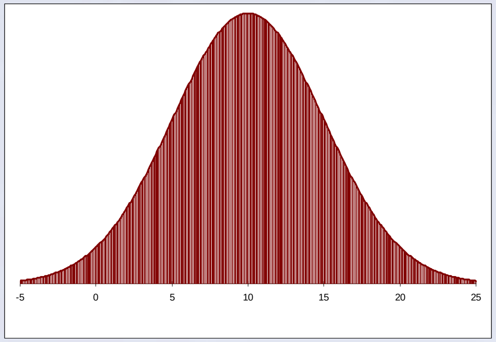
- (Put/Call type): Valuing a business (or any project, such as R&D), assuming that it may be closed/hibernated/reopened/expanded according to futureconditions
- (Choose type): Deciding as late as possible on the ultimate use of a piece of land (e.g. residential/commercial) e.g. depending on market value of each. E.g. How much premium to pay to a builder who can conduct the works more quickly, so that usage can be decided as late as possible
- (Switching): What premium to pay for a piece of capital equipment that can run on either oil or gas, or for an airline ticket that allows flexible travel date
- (Informational): Whether to invest fully in a project now, or to conduct an exploratory phase (at some cost) in order to establish whether a second stage of investment could be justified. How much is it worth investing in Phase 1?

Link to risk analysis

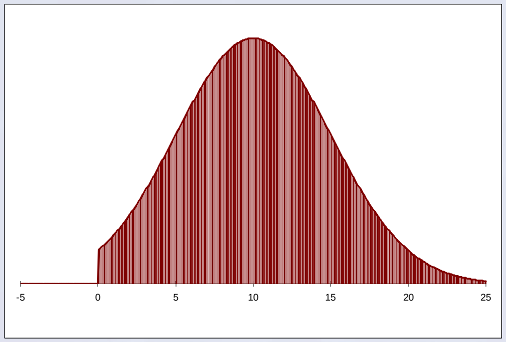


Focus of analysis

- *Static*: how profitable is the project?
- Value = + $10m



- *Risk analysis*: What is the range and likelihood of possible values (i.e. are all outcomes acceptable)?
- Expected value = +$10m is <u>unchanged</u> (assuming base case is based on mean, not mode); worst case highly negative



- *RO analysis*: Is there extra “hidden” value (due to different future courses of action or additional contingency measures)?
- Expected value > +$10m; worst case is less severe (best case may also be better)

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Decision, Risk and RO analysis

- Risk analysis versus static decision analysis
  - More structured and rigorous thought
  - Formalizes the definition of the base case
    - Whether that is the valid case for making a decision (e.g. mean versus mode)
    - Include some mitigating actions in the base case analysis
  - Captures variability of outcomes, so that this can be reflected in the decision process (incl. subjective component) e.g. reject a decision that is profitable on average
- RO is a special case of risk analysis, and will in some circumstances lead to a better decision than basic risk analysis
  - A risk analysis without a consideration of RO may be sufficient when your opportunities to react differently to risk are small (or when the risks are small)
  - The key to a good real options analysis is structured thinking about the nature of the decisions, risks and ways to respond to risk, and whether this is important in a specific decision situation

Real Options: Main uses

- Rigorous valuation/decision-making basis regarding projects where there is large uncertainty and ability to respond
  - Especially projects that may be developed in phases, and/or where further information may be purchased (tests conducted)
- Facilitating discussion of decision situations
  - Make explicit those otherwise implicit assumptions which may lead to people having differing views about a decision situation (e.g. wanting to support an apparently unprofitable project)
  - Explaining decision-making behaviors (e.g. indecision when faced with an apparently clear decision)

Moot points

- Does traditional NPV analysis underestimate value?
  – Depends on model calibration and historic versus future RO
- What is the appropriate discount rate?
  – Presumably, the ability to react flexibly to different outcomes should reduce the risk, and hence the choice of the discount rate

Project Valuation

- Traditional methods (e.g. NPV) fail to accurately capture the economic value of investments in an environment of widespread uncertainty and rapid change.
- **ROA** applies put option and call option valuation techniques to capital budgeting decisions.
- **ROA** forces decision makers to be explicit about the assumptions underlying their projections, and is increasingly employed as a tool in business strategy formulation.

Project Valuation using Decision Analysis

Project 1	
Phase	Pre-Clinical
Launch Year	2009
Probability of Technical Success	5%
Net Sales (if success)	$ 4753 million
Pre-launch costs (including R&D cost)	$ 152 million

Project 1	
Discount rate	10%
Present Value Net Sales	$ 1174 million
Present Value pre-launch costs	$ 96 million
Net Present Value	$ 1078 million

- **Sales Forecasts:** produced by Strategic marketing department; based on unmet medical need, patient population, quality of the label, pricing, market share, and reimbursement policies
- **R&D costs**: historic data and specific characteristics of the project to estimate R&D costs
- **Discount rate**: weighted average cost of capital is used to value projects ~10%
- **Probability of Technical Success (PTS):** combination of industry benchmarks figures and historical data + peer assessment

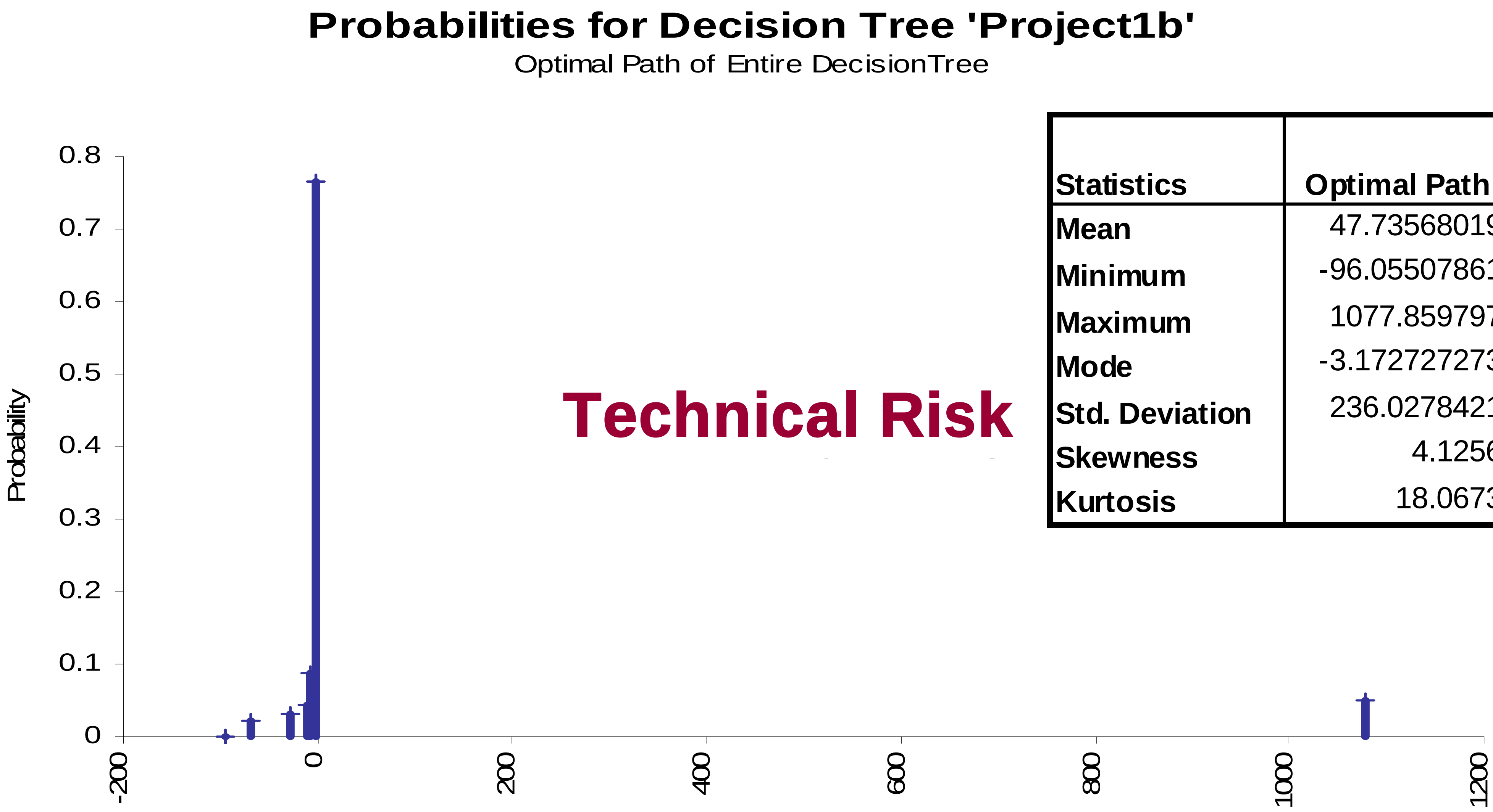
Project Valuation using Decision Analysis

PROJECT 1

Year	Phase	Probability of Technical Success	Cumulative Probability	Gross Sales	R&D cost	COGS	M&S	Royalties	Overhead	Total Cost	Contribution	Expected Contribution
2003	Pre-Clinical	23.29%	100.00%		$3.49					$3.49	-$3.49	-$3.49
2004	Phase I	62.92%	23.29%		$3.97					$3.97	-$3.97	-$0.92
2005	Phase IIa	69.50%	14.65%		$7.63					$7.63	-$7.63	-$1.12
2006	Phase IIb	69.87%	10.18%		$25.22					$25.22	-$25.22	-$2.57
2007	Phase III	71.39%	7.12%		$51.12		$11.43			$62.55	-$62.55	-$4.45
2008	Regulation	98.00%	5.08%		$26.47		$22.79			$49.26	-$49.26	-$2.50
2009	Launched	100.00%	4.98%	$40.82		$2.04	$61.22		$1.22	$64.49	-$23.67	-$1.18
2010	Launched	100.00%	4.98%	$136.05		$6.80	$81.63		$4.08	$92.52	$43.54	$2.17
2011	Launched	100.00%	4.98%	$340.14		$17.01	$85.03		$10.20	$112.24	$227.89	$11.35
2012	Launched	100.00%	4.98%	$448.98		$22.45	$67.35		$13.47	$103.27	$345.71	$17.21
2013	Launched	100.00%	4.98%	$503.40		$25.17	$75.51		$15.10	$115.78	$387.62	$19.30
2014	Launched	100.00%	4.98%	$544.22		$27.21	$81.63		$16.33	$125.17	$419.05	$20.86
2015	Launched	100.00%	4.98%	$544.22		$27.21	$81.63		$16.33	$125.17	$419.05	$20.86
2016	Launched	100.00%	4.98%	$544.22		$27.21	$81.63		$16.33	$125.17	$419.05	$20.86
2017	Launched	100.00%	4.98%	$544.22		$27.21	$81.63		$16.33	$125.17	$419.05	$20.86
2018	Launched	100.00%	4.98%									
2019	Launched	100.00%	4.98%									
2020	Launched	100.00%	4.98%									
										TV	$1396.83	$69.54
										NPV	**$1,077.86**	**$47.74**

Discount rate	10.00%
Overhead allocation rate	3.00%
Sales Decline	20.00%

Project Valuation using Precision Tree



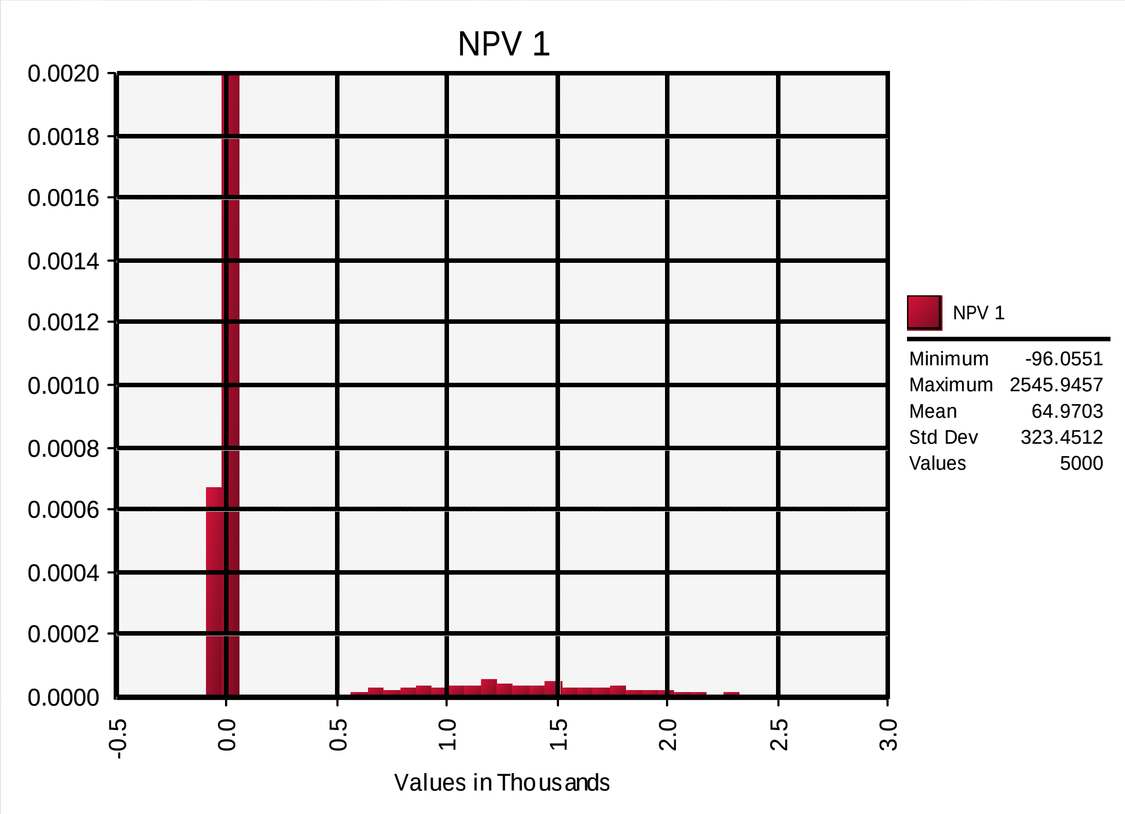
Statistics	Optimal Path
Mean	47.73568019
Minimum	-96.05507861
Maximum	1077.859797
Mode	-3.172727273
Std. Deviation	236.0278421
Skewness	4.1256
Kurtosis	18.0673

Project Valuation using Precision Tree

- Problem can be expanded easily:
  - Adding a chance node representing a competitor’s entry to the market
  - Introducing multiple market scenarios at launch
  - Including multiple execution modes at Phase III (different investment amounts)
  - Switch options
  - Analyzing sensitivity of the decision to the assumptions of the model

Project Risk Analysis using MCS with @RISK

- With high probabilities of failure how sure are we to invest in such risky investment?
- Risk analysis can uncover variability in NPV given uncertainties in revenues generated by successfully launched drugs



Technical & Commercial Risk

Options and Real Options: Differences (selected)

- **Tradability of underlying asset (and/or of the derivative).** An assumption that these are traded assets is absolutely fundamental to value financial market options (as it allows risk-free replicating portfolios to be created, which then allows one to by-pass the issue of how to discount for risk). But this assumption is clearly not true for almost all real options.

- **Option maturity and exercise.** Financial market options are usually exercisable on a fixed date, or at worst have a defined finite life (and are exercisable any time before the end of this life). This is often not the case for real options - and complicates further the issue of when and in what circumstance it makes sense to exercise the option

- **Contract definition and influence of participants**: Financial market options operate under a defined structure and contract, and where market participants are unable to influence the value of the contract. Real options structures and values can be influenced by management e.g. by negotiation

Options and Real Options: Similarities

- The value of the option is a function of a random variable (i.e. of the random price of the underlying asset)
- The payoff function is usually a non-linear function of the variable i.e. different decisions that are taken as the value of the variable changes
- Many of the factors that increase/decrease options values also increase/decrease real options values for analogous reasons (e.g. volatility, time to maturity, strike/cost of exercise etc.)

Effect of parameters on BS option values

	Call	Put	Comment
S ↑ Current price	↑	↓	Intuitive
E ↑ Exercise Price	↓	↑	Intuitive
τ ↑ Time to Expire	↑	↑ for US options ↓ when S low, ↑ when S high for European options	Reflects possibility that European put option when deep in the money may lose value as time to maturity increase
σ ↑ Volatility	↑	↑	Intuitive
r ↑ Risk-free interest rate	↑	↓	Increase in r decreases PV of exercise value (or increases likelihood that risk-neutral random walk for call will end in the money)
D ↑ Constant Dividend Yield	↓	↑	Higher dividend increases value of holding stock rather than option

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Black-Scholes Assumptions

- Brownian motion of underlying asset
- Underlying is traded, with:
  - No restrictions on short-sales
  - No transaction costs
- Known volatility
- Constant and continuous dividend yield
- No arbitrage on risk-free portfolios
- Constant risk-free interest rate
- European options (i.e. exercisable only at expiry) for validity of closed-form solution (partial differential equation is always valid)

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Real Options: Summary

Key points

- Risk (variability in future outcomes)

AND

- Non-linearity (i.e. reacting differently depending on the outcome)

Special points

- Exercise of option (issue of optimality)
- Choice of discount rate
  - CAPM
  - Risk-free/risk-neutral

Key analytic steps: structured thinking

- Develop good qualitative understanding of the situation
  - Identify the sources of randomness/uncertainty
  - Identify the different decision possibilities that could be taken in the future (i.e. how flexibility in the decision can be used to create value when future events have uncertain outcomes)
  - Map which decision should be taken for each of the random outcomes (optimal exercise)
- Build a quantitative model to value the decision