Analyzing Strategic Options with Decision Tree Models

"Chance favors the prepared mind."
Louis Pasteur (Lecture 1854)

Framing Effects – Interaction between Decisions with Risk

You are faced with the two concurrent decisions below involving two different projects. First examine the two decisions, then indicate your pair of choices.

Decision 1: *Choose A or B*

A. a sure gain of $2400

B. 25% chance to gain $10000
75% chance to gain nothing

Decision 2: *Choose C or D*

C. a sure loss of $7500

D. 75% chance to lose $10000
25% chance to lose nothing

Number of people in this group choosing each combination

	C	D
A		
B		

Typical choice combinations (%)

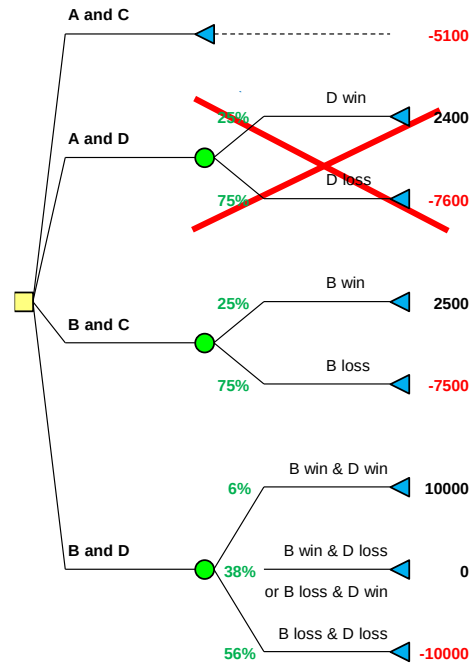
	C	D	
A	10	50	60
B	10	30	40
	20	80	100

Framing – Combining the decisions

Both decisions combined:

(B and C) = (A and D) + 100

(B and C) dominates (A and D)



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Decision Tree Analysis – Main ideas

- Identify the key **Decisions** and **Uncertain Events** in a project, then connect them together in a **Tree Diagram**
- Use **Expected Value** (EV) or similar criterion to evaluate the options
- Advantages:
  - Account for **contingencies** in decisions, capture the **interdependence** of sequential/recourse decisions
  - Reason on entire **chain of decisions** (a strategy), not single decisions
  - Obtain more **defensible valuations** of projects, reflecting the value of **flexibility** provided by **options**(*)
  - Decisions will be **forward-looking**: earlier decisions driven by later opportunities

(*) Option = the possibility to make a decision

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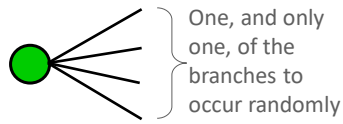
Structuring Strategic Options with a Decision Tree

Important to distinguish between:

- the **decisions** to be made (you control, you pick a branch):

Computation at Decision node: Select the branch with best Expected Value

- the **uncertainties** faced (you do not control, it's random):



Computation at Event node: Calculate Expected Value across all branches

All the nodes are connected in a tree structure to represent possible scenarios or paths.

A best strategy is a set of conditional decisions that yields best EV.

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Decision Tree Computations

➢ ***Data***

- **Intermediate payoffs** (positive or negative): on *any* branch
- **Probabilities:** on *Event* branches only.
  Probabilities of an event branches should sum to 1.0.
- **Final payoffs:** at *Terminal* nodes, equal to the sum of intermediate payoffs along the path leading to the terminal node

➢ ***Algorithm***

Solve *last* decisions *first*, then work *backward*

(Relax: the software does all this for us)

0. Start with last decision tree stage
1. For each event node: calculate expected value (EV)
2. For each decision node: retain only the branch with best EV
3. Move backward to preceding decision stage: repeat (1) and (2)

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Example: Sizing up a new facility

Your company needs to set up a new facility dedicated to a new product/service.

- **Major uncertainty:** **scale of adoption of the new product?**
  - *Scale of adoption: large or low*

  NPV projections have been calculated for each case

- **Decision:** **what capacity to develop <u>now</u>**
  - *Large facility: suited to meeting large scale adoption*
  - *Small facility: suited to meeting low scale adoption*

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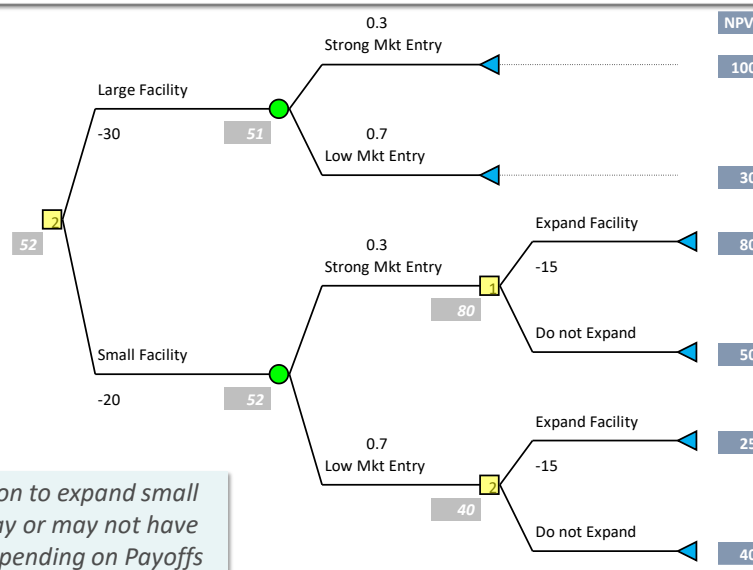
Sizing up a new production facility



The option to expand small plant may or may not have value depending on Payoffs and Probability scenarios.

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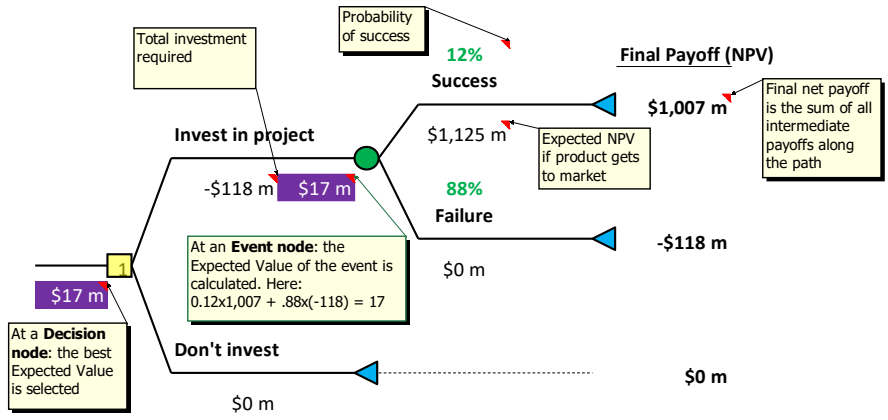
Valuation of a start-up project: simple decision tree

Elementary decision tree…



… shows the project has an EV of $17m

Wait, it's not that simple! Failure could occur in early development phases

→ need to account for this in the decision tree

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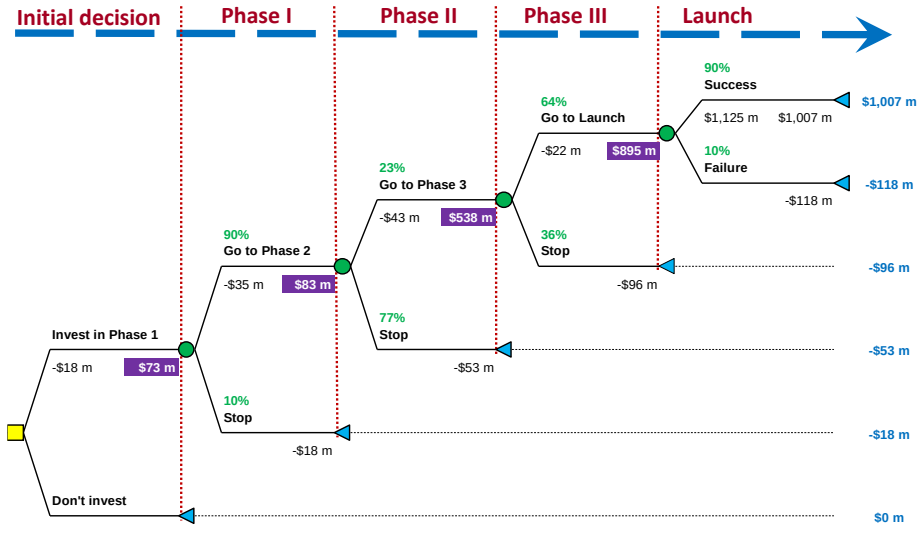
Valuation of project: tree model with development phases



*… now reveals an EV of **$73m**, due to the **option of stopping** at various stages*

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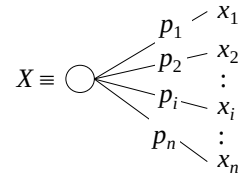
How to evaluate a risky prospect?



Expected Value (EV):

Multiply each outcome of the prospect by its probability of occurrence, and sum across all outcomes.

$$\mathrm{E}[X] = \sum p_i x_i$$

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Facts about Expected Value

- EV decision rule: accept project if EV > 0; reject if EV ≤ 0
- EV > 0 means that the upside of the gamble outweighs its downside, in a statistical sense
- EV ignores project risk and decision-maker's aversion to risk
- EV is appropriate if:
  - Many projects
  - No single project may lead to catastrophic outcomes (e.g. bankruptcy)

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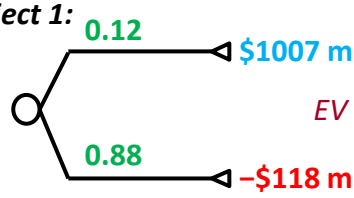
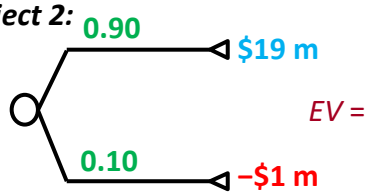
Expected Value ≠ Risk

Project 1:



EV = 1007×0.12 + (−118)×0.88 = **$17 m**

Project 2:



EV = 19×0.90 + (−1)×0.10 = **$17 m**

Which project do you find riskier?

Project 1 seems riskier than Project 2, yet they have same EV

Conclusion: Expected Value does not reflect risk!

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Decision Tree can help manage the uncertainties…

Some questions to consider:

- ✓ How does the valuation of the project evolve at each hurdle? Implications for building in **options** (e.g., licensing), or contingencies in acquisition,…?
- ✓ Which uncertainties are most **critical**? How to price the uncertainties?
- ✓ Can we do some testing? **Front-load** some activities …? Which ones? How to **prioritize**?
- ✓ Any salvage/residual value if the project is aborted at any stage? Is it factored in the evaluation?

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Tips for Building Decision Tree Models

- Recognize it is a **trial-and-error** process
- Stay in the "**big picture**", with homogeneous level of detail (*roadmap analogy*)
- Do not be paralyzed by **ambiguity** and "unknown unknowns"
- Focus on problem **structure**, i.e. **framing**, not data availability
- Typically **start with a Decision** node
- Important to distinguish between **actions** (decision nodes) and **beliefs** (event nodes)
- Ask: What are the **critical hurdles** of the project? → these are event nodes
  What are **key decision/review** points, milestones,**…** ? In what **sequence**?
- Follow **chronology** of decisions, events, information acquisition, etc.

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Uses of Decision Tree models

- **Strategic planning**
- **Managing innovation**
- **Technology development**
- **Evaluate options and flexibility, e.g.:**
  - Abandon, "pull the plug"
  - Exit
  - License, outsource
  - Expand, scale up or down
  - Switch to new device or technology
  - Split technology into separate applications

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Decision Tree Models

❖ **Advantages**

- can, in principle, model any decision problem
- enhance/promote **clarity of framing**
- support **scenario analysis**, **qualitative reasoning**
- facilitate **strategic, forward**-thinking
- focus on **terminal** (not intermediate) payoffs
- improve **communication** – *a picture worth a thousand words*
- facilitate **real options** / **information** valuation

❖ **Limitations**

- **discrete** representation of decisions and uncertainties
- multiplication of branches → can grow **unwieldy**
- dealing with "**Known Unknowns**" only!

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Scan this QR code to go to Google Form:

TreePlan success?

Responses are anonymous

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