Games Against Nature: Decision Making Under Uncertainty I

Today's topics:

1. A Simple Decision
2. Introduction to Decision Analysis
3. Structuring the Decision
4. Influence Diagrams
5. The Glix Case

(See Dixit & Skeath, 2nd: pp. 222–228, 3rd: pp. 251–261.)

The Simplest Decision — Case 1

The simplest decision under uncertainty —
calling a coin toss: you win $10 nothing.

— Highlights some concepts which are useful in more complex decisions.

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4. And for imperfect information?

Everyone write down your answers to Questions 2 and 3.

Coin toss

_____ values this game at ___¢.

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_____ values *Perfect Information* at $_____

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3. So, to be consistent:

Consistency Check ...

Minimum selling price
(The *Certain Equivalent*)
+

Consistency Check ...

Minimum selling price
(The *Certain Equivalent*)
+
***Value of Perfect Information* (VPI)**
=

Consistency Check ...

Minimum selling price
(The *Certain Equivalent*)
+
***Value of Perfect Information* (VPI)**
=
Maximum Payoff

But why?

The Value of Imperfect Information
must be less than
the Maximum Payoff
minus
Minimum selling price
(The Certain Equivalent)

Calling the Toss

Concepts:

➢

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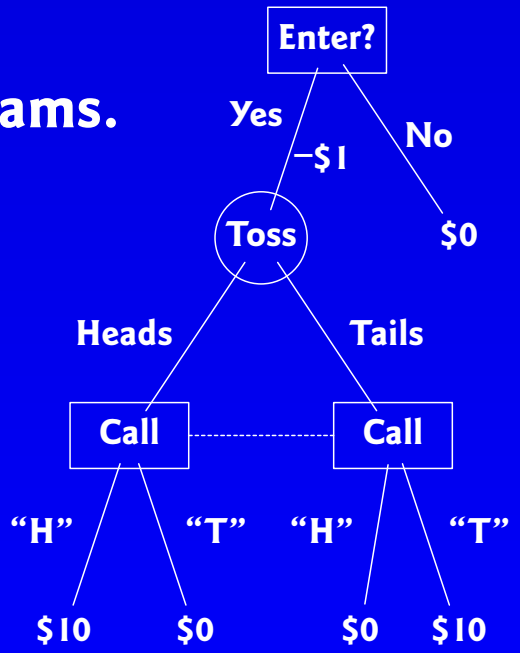
- & Influence diagrams.



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6. Risk averse or risk preferring or risk neutral?

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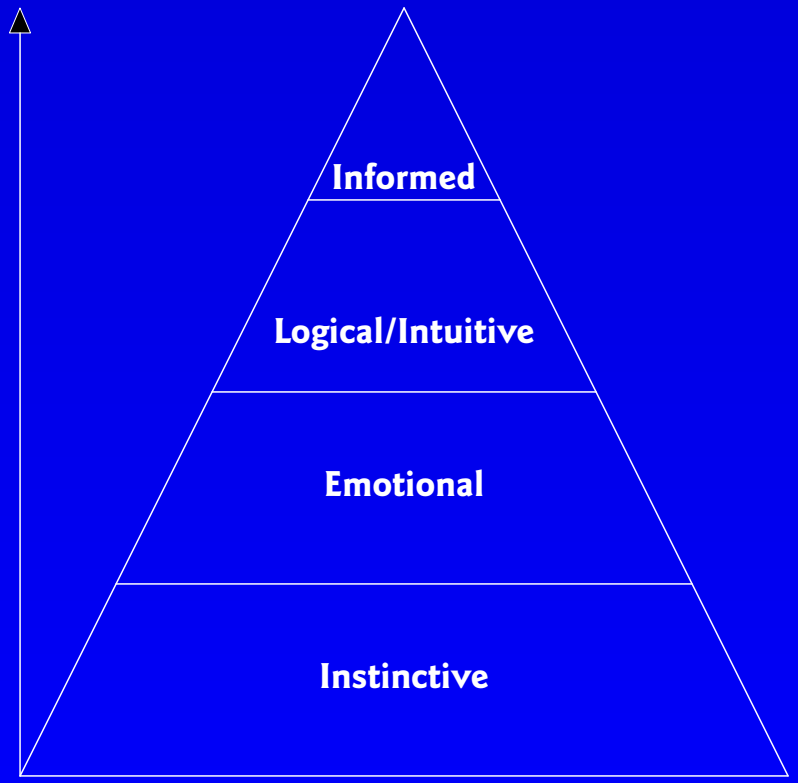
3. Her *value of information*: limited by the Value of Perfect Information, a function of the probabilities and payoffs.

Decision Analysis: Games Against Nature

The Decision Response Hierarchy



The Decision Response Hierarchy

Moving up the hierarchy corresponds to increasing consciousness, clarity, and power.

Which response do you use most often in making decisions?

- ☐ **Informed**
- ☐ **Logical or Intuitive (learned)**
- ☐ **Emotional**
- ☐ **Instinctive**

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A technique for helping make decisions, and avoiding pitfalls.

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- **The value of imperfect information.**
- **Utility and risk aversion.**
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- Risk attitude

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- *Gaining insight* into the decision problem

  — the numbers should always be subservient to the insights gained.

What Is Decision Analysis?

Decision analysis *is*:

> **A methodology based on a set of probabilistic frameworks which facilitates high-quality, logical discussions, leading to clear and compelling actions by the decision maker.**
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> **— insights, not just numbers.**

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Decision analysis is *not*:

- A method for justifying decisions already made.
- Cost-benefit analysis
- A cookbook

Decision analysis provides answers to questions such as:

- **How risky is this project?**
- **Which plan do we follow?**
- **Which assumptions are most important?**
- **What is the project's potential?**
- **Should we gather more data?**
  (and if so, what's the maximum we should pay?)

Beginning Principles:

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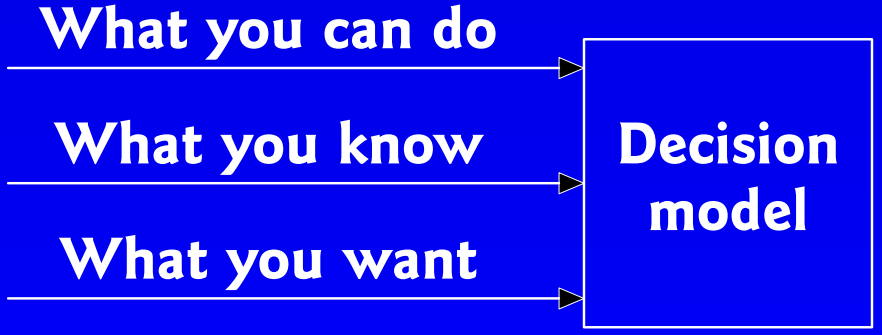

The Decision Analysis Process.

Decision analysis is a three-stage, quality process. But if at any step in the process the decision becomes obvious, you should stop and make the decision.

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1. ***Structuring:*** **Frame the Right Problem**
   - ➢ **Clarify the decision.**
   - ➢ **Raise and sort issues.**
   - ➢ **Generate creative alternatives.**
   - ➢ **Model the problem.**

The Decision Analysis Process — Stage 2

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2. *Evaluation:* Use Logical Thinking
   - ➢ Discover what is important.
   - ➢ Apply an appropriate risk attitude.
   - ➢ Determine the maximum value of new information.

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3. *Agreement:* Have Commitment to Action
   - ➢ Check for refinement.
   - ➢ Agree on course of action.
   - ➢ Implement course of action.

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***Descriptive* decision analysis is a present-state approach, describing how things *are*.**

***Normative* decision analysis is a future-state approach, describing how things *should be*.**

Why Decision Analysis?

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Why Decision Analysis?

- ***Decision making*** **is at the heart of most technical, business and governmental problems, not to mention one's private life.**
- **Decision making requires the study of *uncertainty*. There are no sure things;**
  risk-taking is inescapable.
  - **How does uncertainty affect decision-making?**
  - **How can one make a rational or prudent decision (a "good" decision) without knowing exactly what consequences will follow?**

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  The *risk premium* equals the expected return less the certain equivalent, when selling.

  Risk aversion can be defined and measured using *utility theory*.

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- Must distinguish between a *good decision* and a *good outcome*.

  Prudent decision-making doesn't guarantee the desired outcome invariably, but should improve the odds.

The Value of Perfect Information?

- Often we can, at a cost, reduce our uncertainty about Nature's future events (using market research, forecasting, statistical analysis). There must be a limit to what we should spend in these endeavours—how much is it?

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  What is a fair price to pay?

Summary of Introduction

We need a methodology to help us make difficult decisions. Decision analysis provides that methodology.

Decision analysis focuses on what we don't know, rather than on refining what we do know.

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Decision analysis has three distinct stages — *Structuring*, *Evaluation*, and *Agreement*.

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To begin structuring the decision, we must first define the problem and the decision criterion.

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  — the decision criterion can be anything that allows the decisionmaker to quantitatively distinguish one alternative from another:

  - Net present value (NPV)
  - Internal rate of return (IRR)
  - Cash flow
  - Goodwill/reputation
  - Others

Brainstorming

Once the problem has been defined, we need to brainstorm and sort issues.

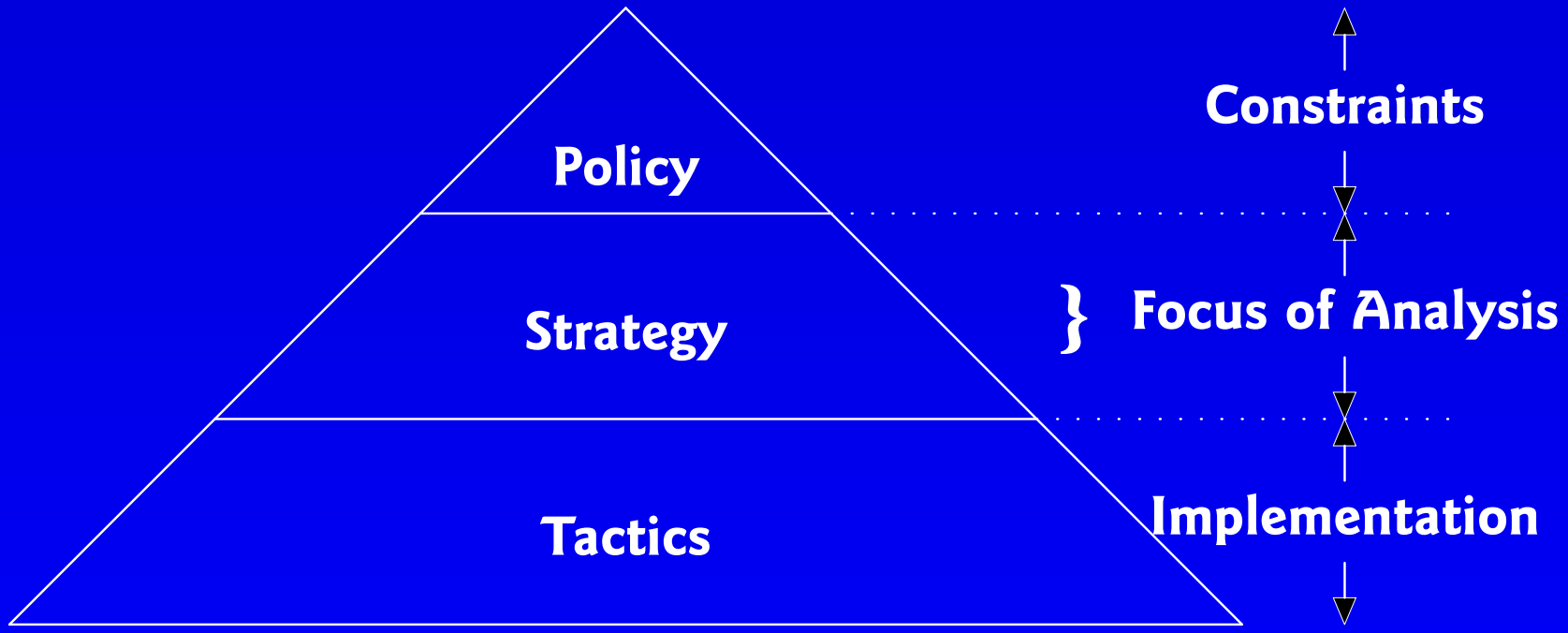
Raise issues.

Separate issues in order to begin problem framing.

Categorise the decisions using the *decision hierarchy,* to help identify the scope of the problem and to separate constraints and implementation from the focus of the analysis.

The Decision Hierarchy

The focus of decision analysis is at the strategic level.



Decision levels.

Policy decisions are constraints.

Strategy decisions are the focus of our analysis here.

Tactical decisions are follow-on implementation decisions.

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- Provide a means to compare alternatives
- Facilitate delegation
- Cannot have circular references or feedback loops
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- Provide a clear, graphical picture of a problem
- Show relationships and relevance
- Facilitate dialogue among team members with different backgrounds and interests
- Provide a means to compare alternatives
- Facilitate delegation
- Cannot have circular references or feedback loops
- Are not flow diagrams

Plotting an Influence Diagram:

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Uncertainties are chance events, ○

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An arrow into an uncertain node ○ means relevance.

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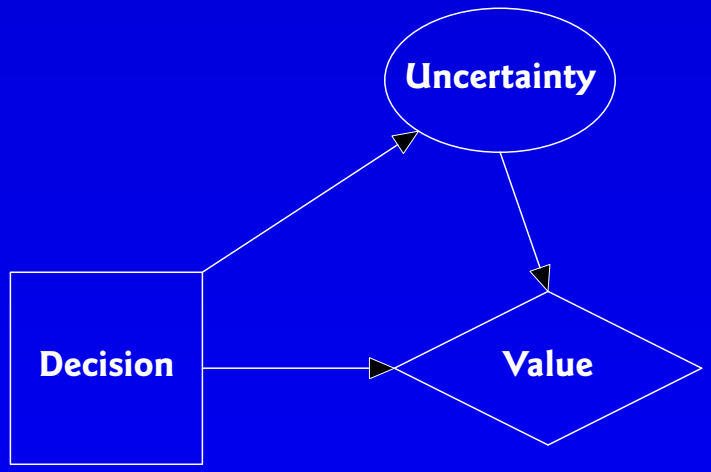
Influence diagrams typically flow from decisions to uncertainties to value.

Arrows indicate relevance and show relationships.



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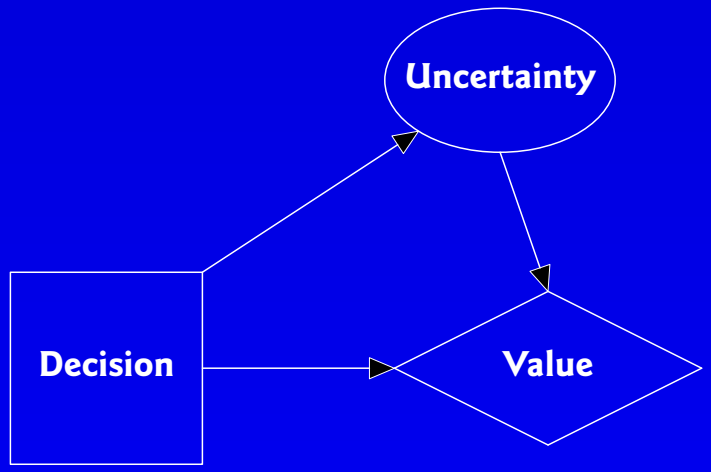

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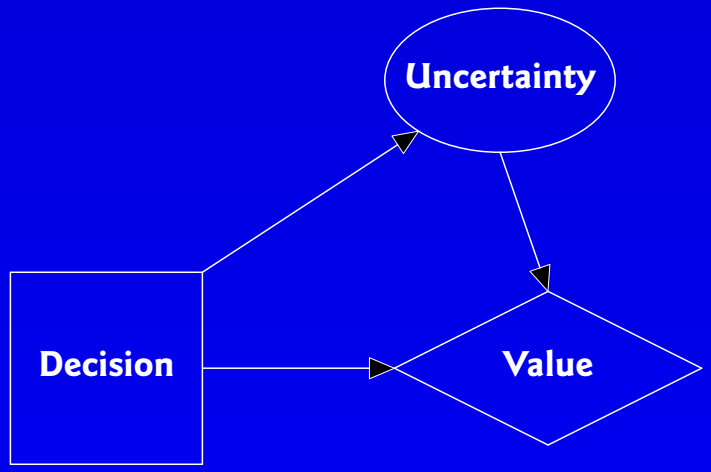

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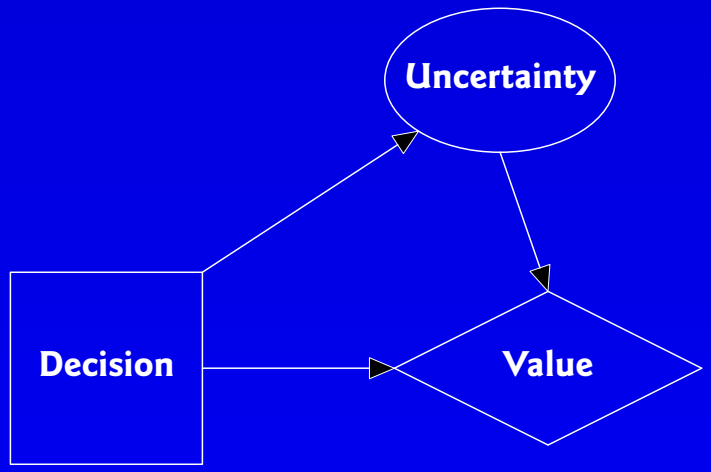

Be careful when adding an arrow: *influence diagrams are not flow charts;* arrows are not necessarily timings.
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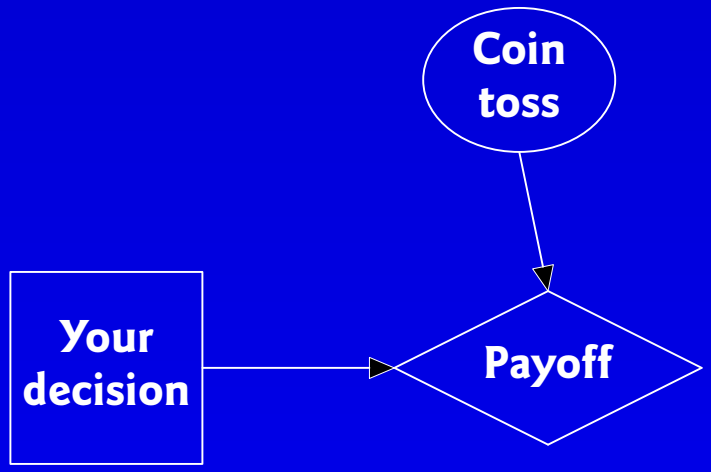
In this I.D., the decision affects the uncertainty, as well as the outcome: e.g. eating and drinking to excess may lead to illness.

The influence diagram for the coin-tossing decision:



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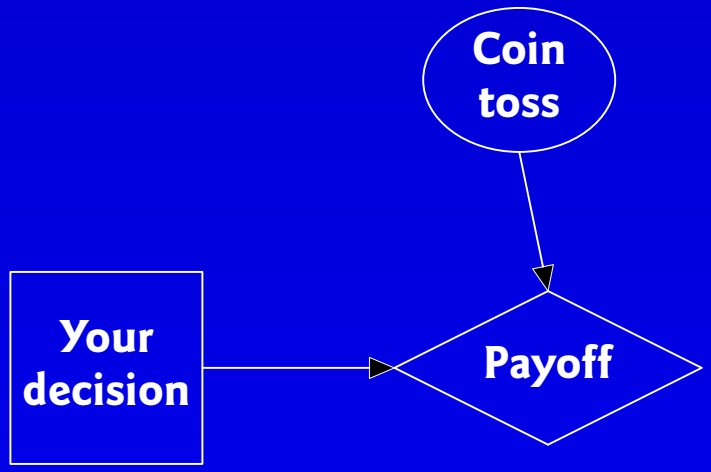

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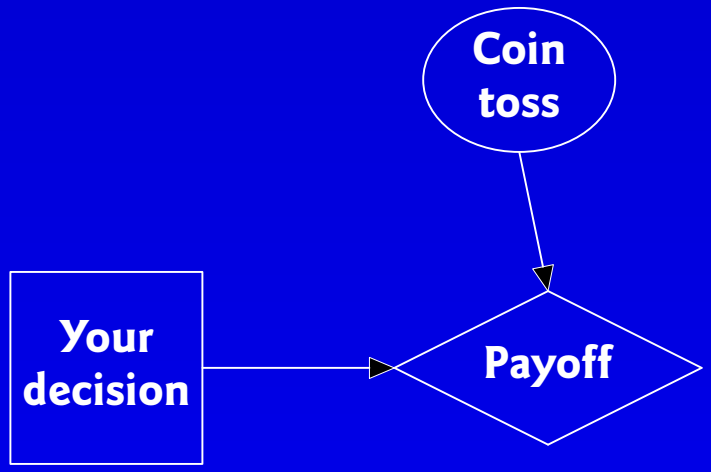

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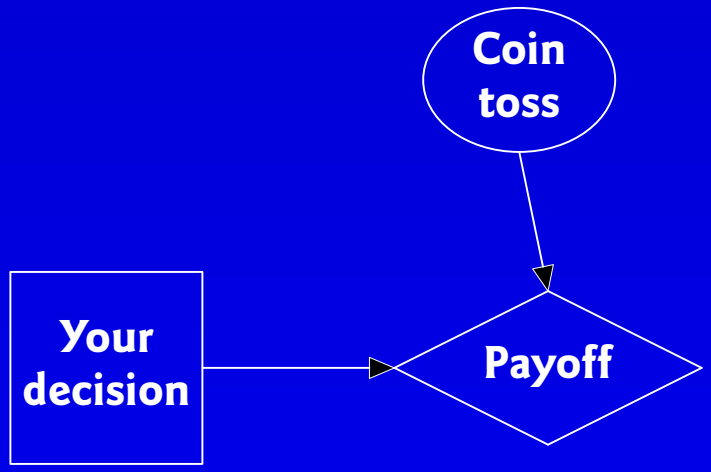

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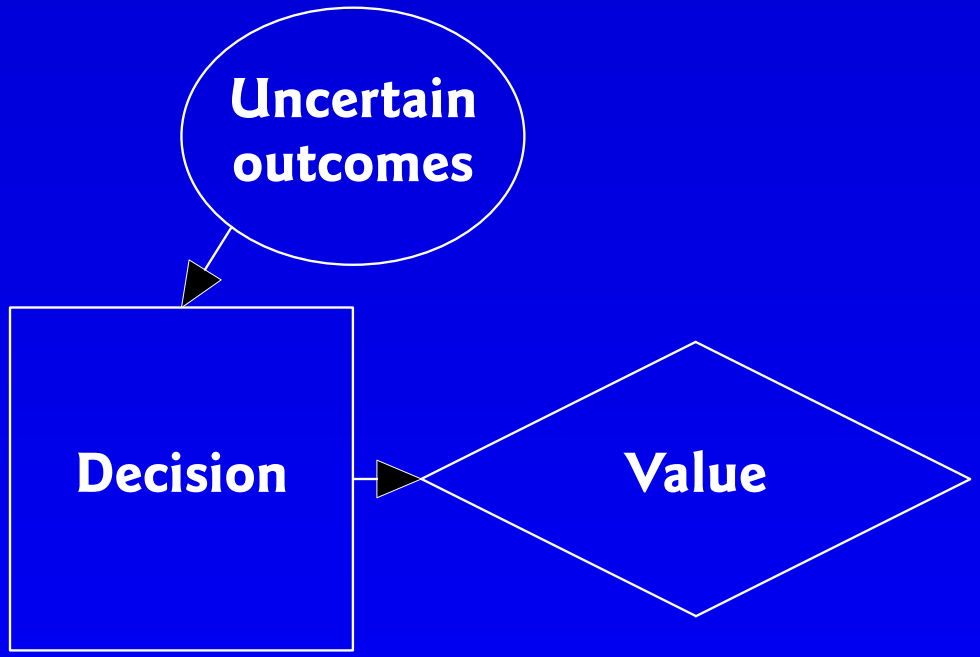
This is a very common Influence Diagram. Other examples?

Decision-making with a Clairvoyant (very unusual)



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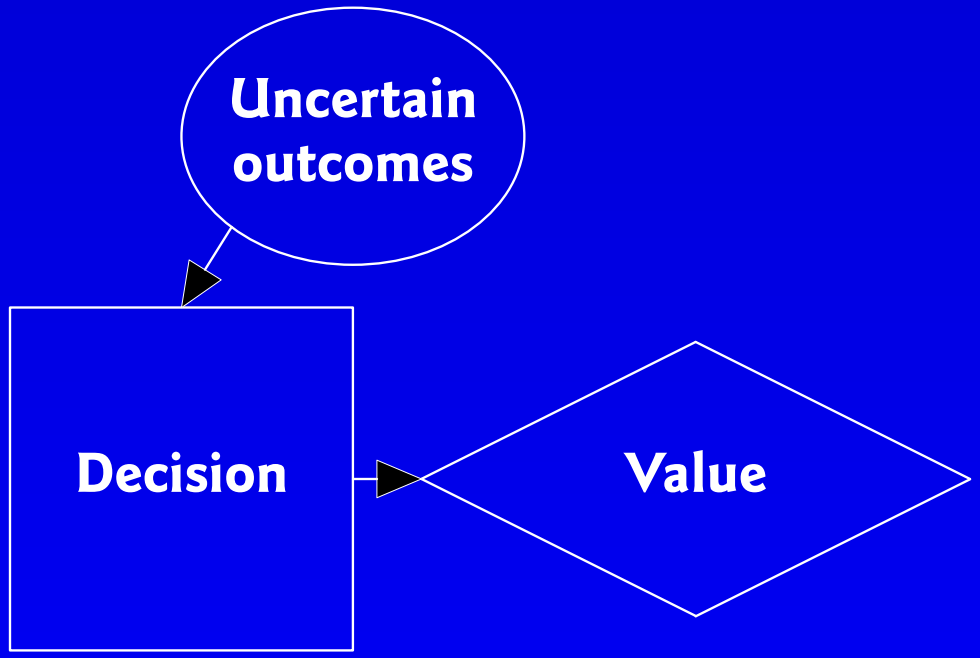
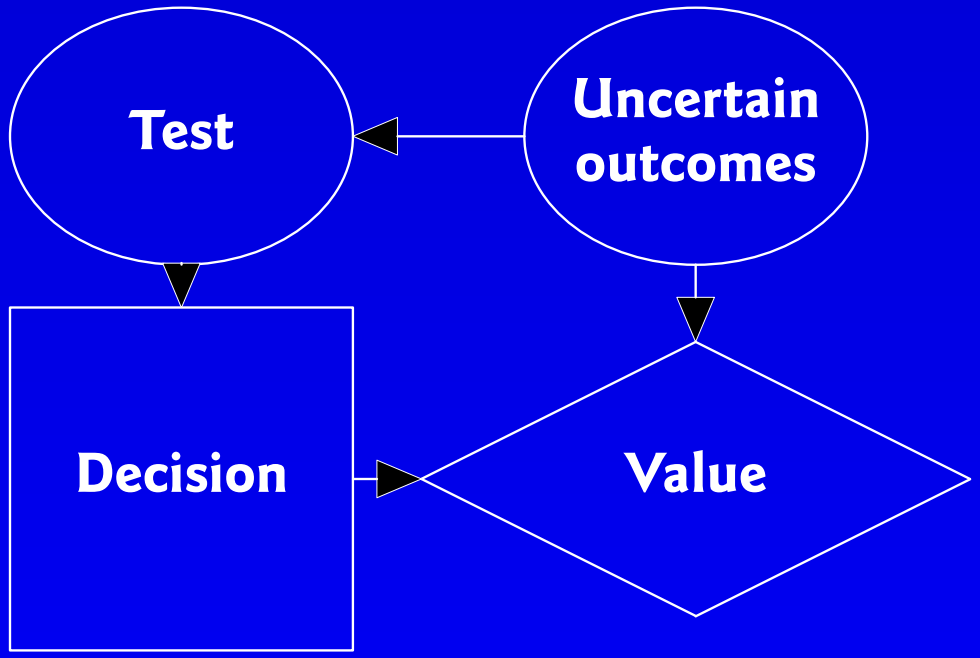


Before you make the decision you know the outcome of the future uncertainty, as shown by the arrow from the Uncertainty to the Decision. Both affect the Outcome. Note: there must have been a prior decision to seek the clairvoyant's knowledge.

Decision-making with Unreliable Information (usual)



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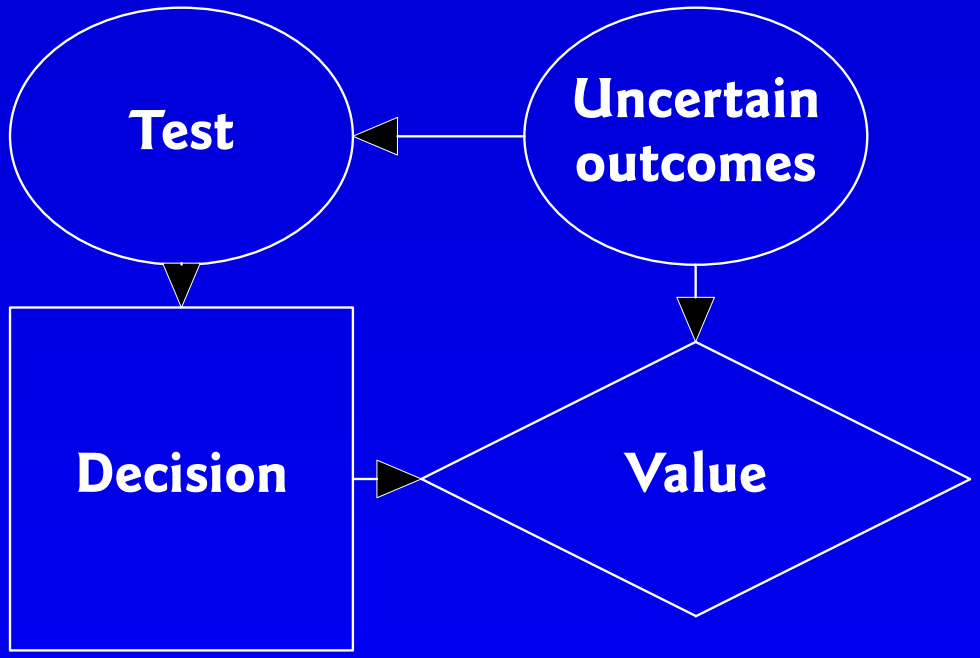
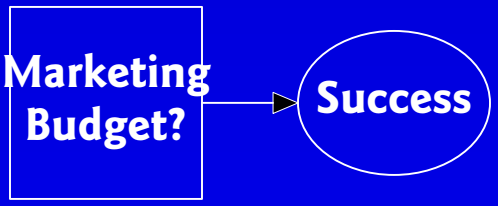


The Uncertainty affects the Test (in an uncertain way, since it's not 100% reliable), the result of which is known before you make the Decision. Note: there must have been a prior decison to undertake the test.

Three Types of Influence — 1. Probabilistic:

(See DATA 3.5 Manual extract in the Readings.)

1. *Probabilistic Influence*



Decision about the Marketing Budget can *influence the probability* of success. If not, then no arrow.

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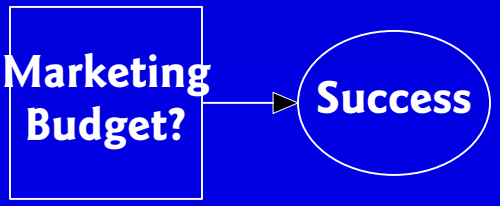

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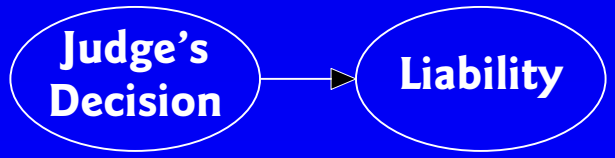
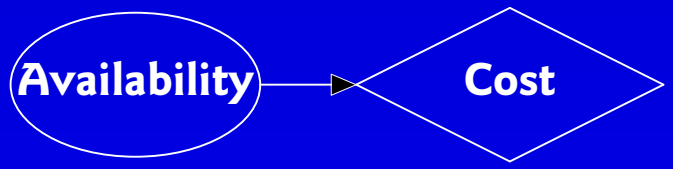


The probability of the defendent's liability *depends on* whether the judge will admit particular evidence. (Not necessarily a time flow.)

Three Types of Influence — 2. Value:

2. *Value Influence*



The manufacturing cost *depends on* the (unknown) local availability of an input.

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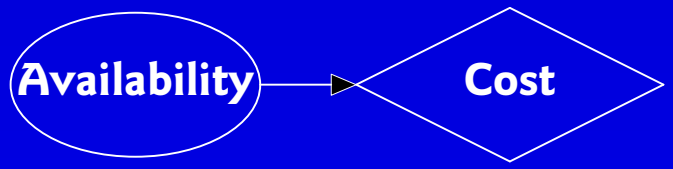

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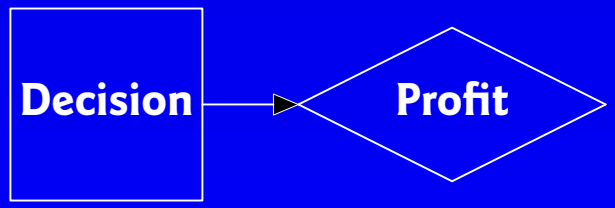
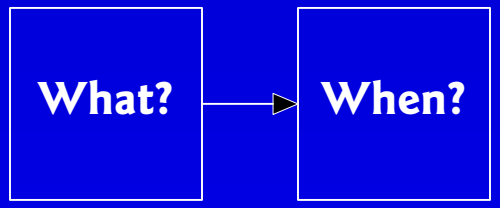


The manager's decisions *influence the profit* of a plant.

Three Types of Influence — 3. Structural:

3. *Structural Influence*



What to make is *decided before* When to make it.

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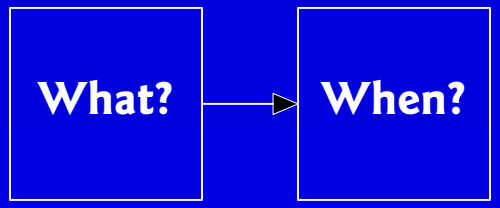

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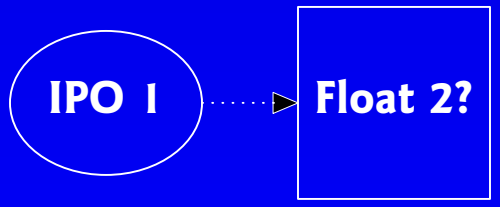

The outcome of floating firm 1 will be *known before* the decision of floating firm 2 is made.

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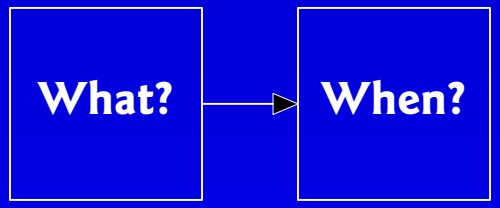

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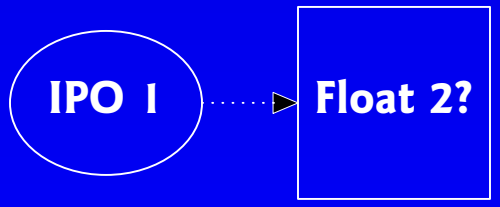
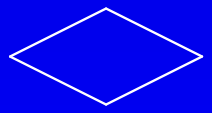


The outcome of floating firm 1 will be *known before* the decision of floating firm 2 is made. ∴ No arrow to the first (or only) decision: the uncertainty is already known or given at the time of decision.

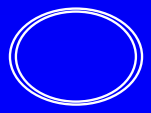
Influence Diagrams — Summary

An influence diagram provides a simple graphical representation of an uncertain decision problem. It contains at least three elements, linked with arrows to show the specific relationships among them:

- *Decisions* are represented by squares □ or rectangles.
- *Chance events* (the uncertainty of which will be resolved before the payoff) are represented by circles ○ or ellipses.
- *Values* or payoffs are represented by diamonds:



- *Deterministic nodes* are represented by double ellipses::



Influence diagrams.

Influence diagrams provide a snapshot of the decision environment at one point in time.

They are not flow charts or diagrams.

They cannot contain cycles.

The arrows must indicate how uncertainty is revealed (all will be revealed before the final payoff, but decisions are made with some uncertainty remaining).

Influence Diagrams — warning

Influence Diagrams are used to focus on decisions involving (future) uncertainty.

The Influence Diagram thus focuses on what might happen to *influence the final payoff* after the (first) decision has been made.

There is no point in plotting any pre-existing influences on the decision-maker that occur before the first decision is made; these are taken as given and (usually) excluded as incoming arrows into the first decison node (a rectangle).

Influence Diagrams are *not* used to examine the "influences" on the decision maker before the first decision is made.

The Glix Case:

The Gaggle Company has developed a new product — Glix.

While you think that Glix has great potential, you are unsure whether Glix will be profitable if brought to market.

Your decision: There are three alternatives facing you:

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1. launch Glix yourself
2.

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-

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- Regulations

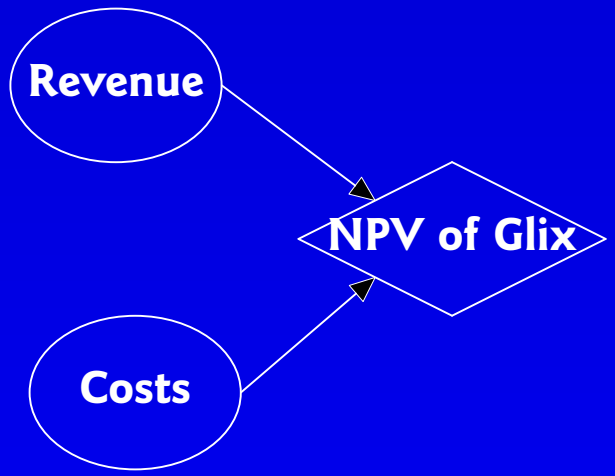
Begin by clarifying the decision and the decision criterion, and work from right to left.

The *decision* is whether: to launch; to sell; or to license the Glix product.

Management have determined that net present value (NPV) is the correct decision *criterion*.

Launching Glix: What are the determinants of net present value?

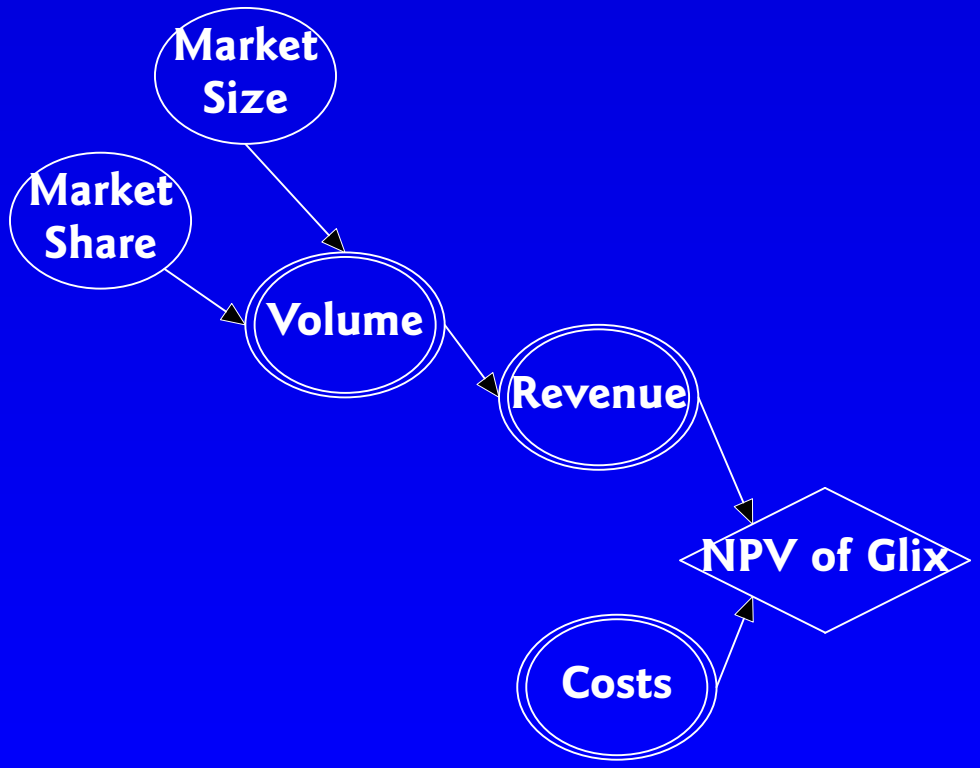
- Revenue
- Cost



What are the determinants of revenue?

What do you need to know the calculate revenue?

Consider the price of Glix to be $5.00 per kilo.



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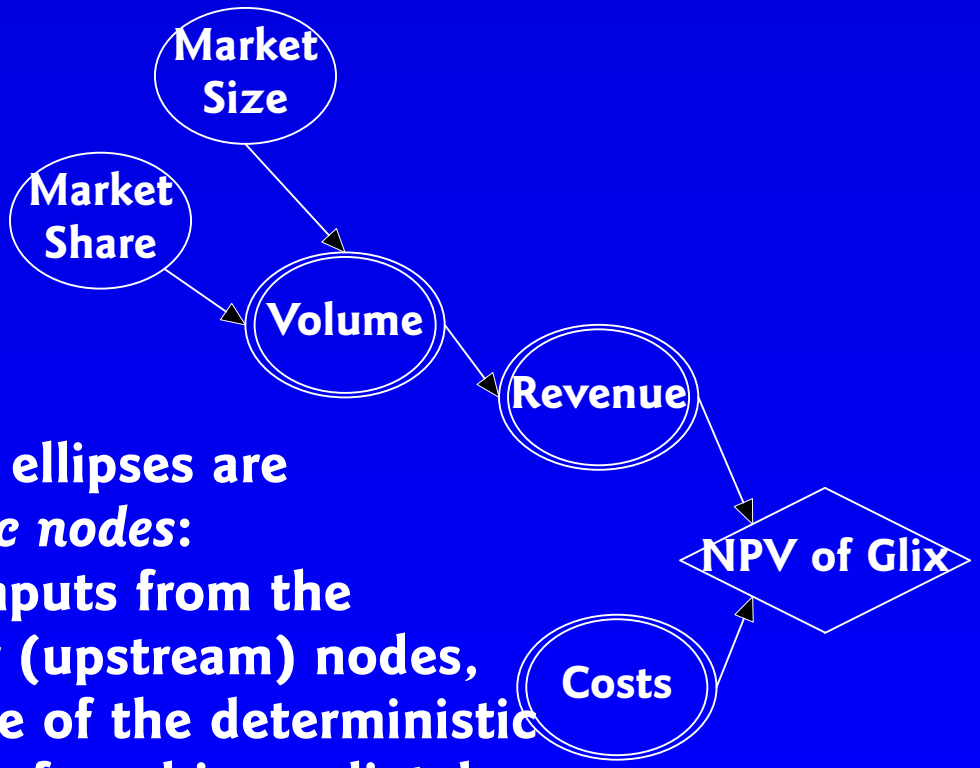
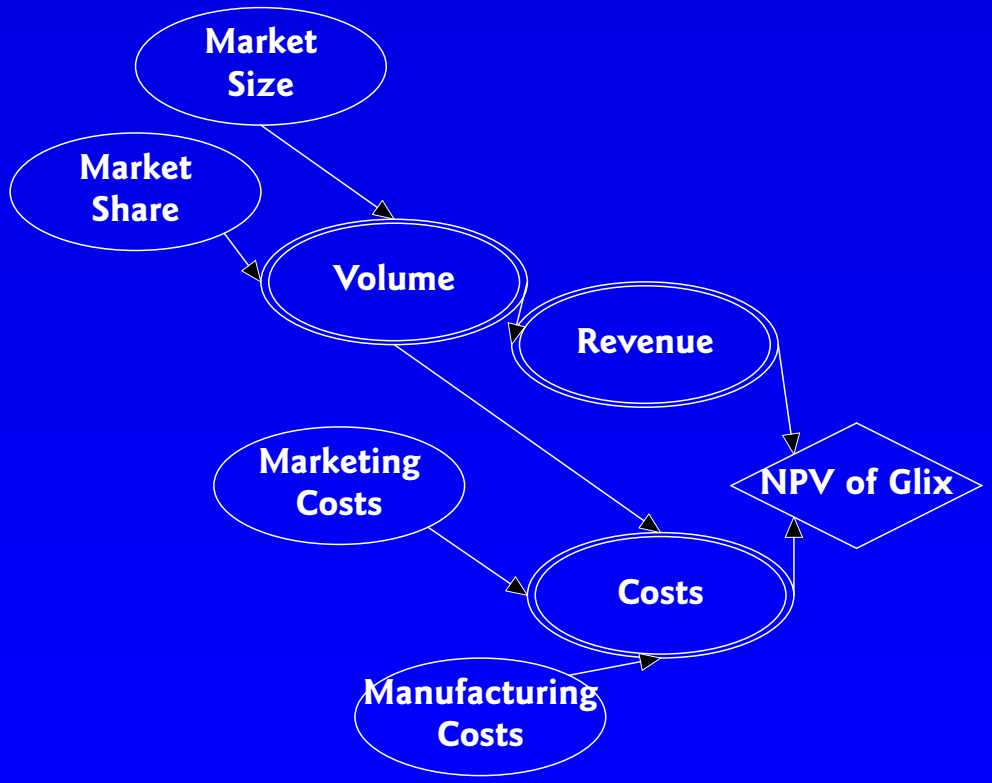


The double ellipses are *deterministic nodes*: given the inputs from the predecessor (upstream) nodes, the outcome of the deterministic node can be found immediately.

Next consider the determinants of cost.

What do you need to know to estimate the costs associated with Glix?

There is a factory in place that will only need minor modifications at a cost of $1,500,000.



Lastly, we need to add the decision.

Which key uncertainties does the decision influence?