1. Decision Analysis: Games Against Nature

1.1 Influence Diagrams

The next step is to model the decision making using influence diagrams. An influence diagram is a simple visual representation of a decision problem. Influence diagrams offer an intuitive way to identify and display the essential elements, including decisions, uncertainties, and objectives, and how they influence each other.

Influence diagrams:

- ➢ 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
- ➢ Cannot have circular references or feedback loops
- ➢ Are not flow diagrams

Plotting an Influence Diagram:

Uncertainties are chance events, ○

Decisions are controllable, □

Values are what you prefer, 

Arrows indicate relevance, →

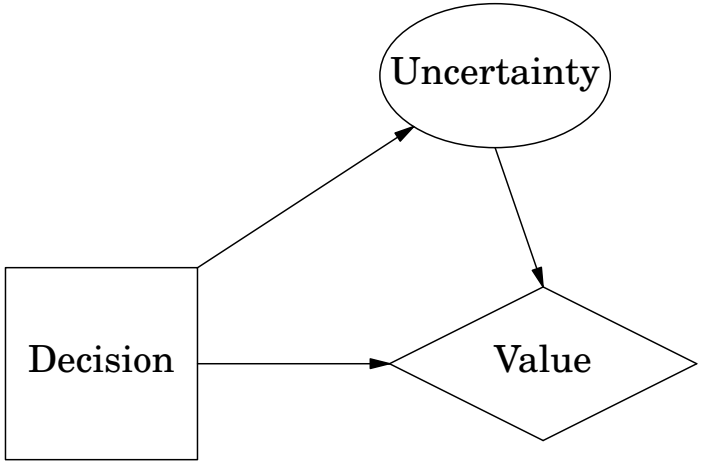
An arrow into an uncertain node ○ means relevance.

An arrow into a decision node □ means is “known”.

An arrow into a value node ◊ means “functional”.

Influence diagrams typically flow from decisions to uncertainties to value.

Arrows indicate relevance and show relationships.

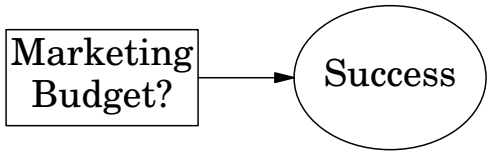


Be careful when adding an arrow: *influence diagrams are not flow charts.* The lack of an arrow says more than having an arrow.

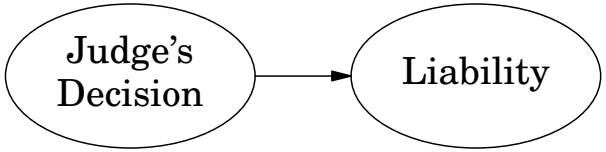
Three Types of Influence — 1. Probabilistic:

(See DATA 3.5 Manual.)

1. *Probabilistic Influence*



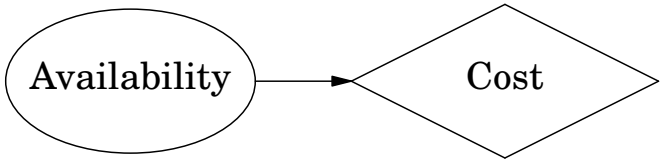
Decision about the Marketing Budget can *influence the probability* of success. If not, then no arrow.



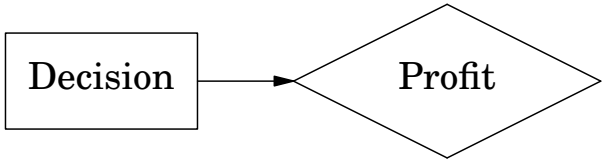
The probability of the defendent's liability *depends on* whether the judge will admit particular evidence. (Not necessarily a time flow.)

Three Types of Influence — 2. Value:

2. *Value Influence*



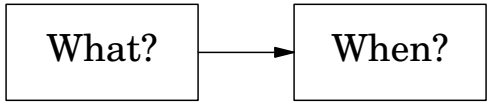
The manufacturing cost *depends on* the (unknown) local availability of an input.



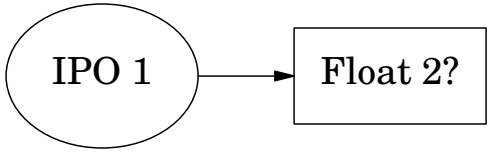
The manager's decisions *influence the profit* of a plant.

Three Types of Influence — 3. Structural:

3. *Structural Influence*

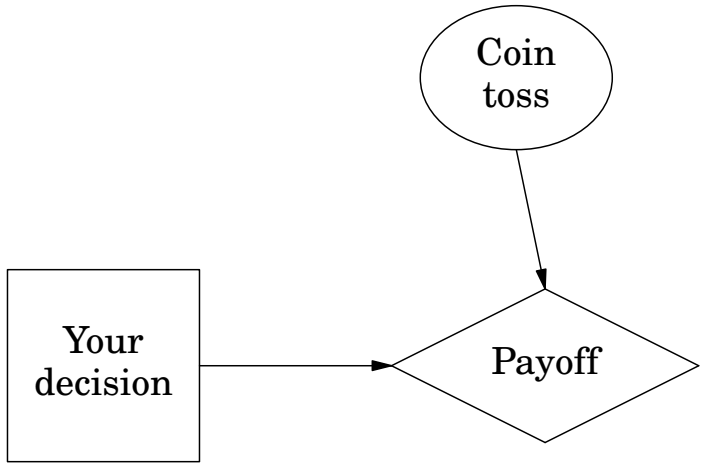


What to make is *decided before* When to make it.



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.

The influence diagram for the coin-tossing decision:



Since your decision (of whether to invest, and, if so, whether to call “heads” or “tails”) does not influence the outcome of the coin toss, there is no arrow from the decision node to the chance node.

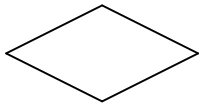
And since you will call the toss before you know the outcome, the arrow from the chance node goes to the payoff node.

This is a very common Influence Diagram. Other examples?

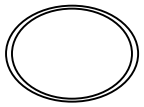
1.1.1 Influence Diagrams — Summary

An influence diagram provides a simple graphical representation of a 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).

1.2 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:

1. launch Glix yourself
2. sell Glix to another company, or
3. licence Glix to all comers

1.3 Summary of Structuring

Influence diagrams provide a graphical description of the essence of the problem.

Software (such as Treeage's DATA or Palisade's Precision Tree for Excel) allows us to model the entire decision as an influence diagram, which can be transformed into a decision tree and solved.

Influence diagrams are also a good communication tool.

The focus of decision analysis should be at the strategic level.

Brainstorming issues and then separating the issues into decisions, uncertainties, objectives, and facts helps to frame the problem.

1.4 Why Use An Influence Diagram?

IDs provide the ability to:

— capture and

— communicate

the essence of a problem in an easy-to-understand manner.

Influence diagrams:

➢ Help to structure the problem discussion,

➢ Identify influences and dependencies between decisions and uncertainties,

➢ Show how the value is created,

➢ Provide a means to identify information sources and to assign tasks,

➢ Develop the logic and structure for the computer decision model.

1.5 Step-By-Step Procedure

IDs as much an art as a science. Focus on developing a clear and meaningful diagram. Ask probing questions. Make sure *not* to develop a flow diagram. IDs do not have feedback loops.

Step 1: Explain to the team why this is important and how it will be used.

Step 2: Consider the essence of the problem:

is it business, marketing, R&D, exploration etc?

Helps to guide the development of the diagram.

Step 3: Put a value node labelled with the decision criterion at the middle of the RHS of the page.

Most diagrams use NPV as the value node, influenced by Revenue and Costs.

Step 4: What piece(s) of information would most help in resolving the uncertainty or determining the value?

Procedure (cont.)

Step 5: Choose one uncertainty influencing the value node, and develop it completely before tackling the other nodes.

Make sure the nodes are clearly defined and specific.

Step 6: Review the uncertainties on the previous issue-raising list: should those missing from the diagram be included?

If not, why not?

Step 7: Identify deterministic uncertainty nodes, designated by double ovals. Can you write the formulas for the value in these nodes?

If not, list the missing information.

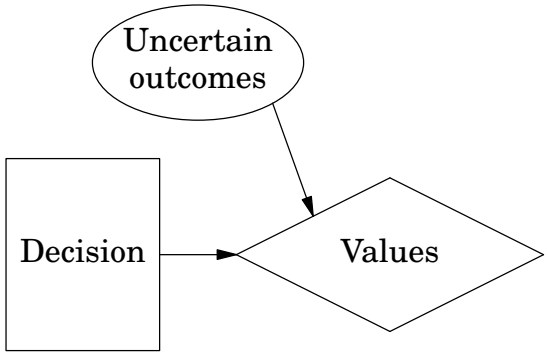
Step 8: Identify information sources and write each source's name by the node it can resolve.

Step 9: Is the diagram complete and has the problem been described accurately?

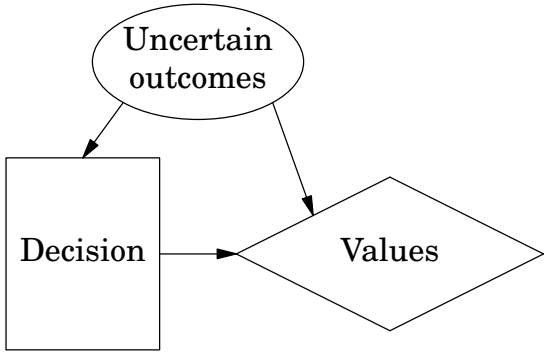
Step 10: Write an information-gathering task list.

1.6 Types of Influence Diagrams

1. Simple, 1-stage, non-strategic decision, then resolution of uncertainty, then payoffs. (Laura's marketing decision)

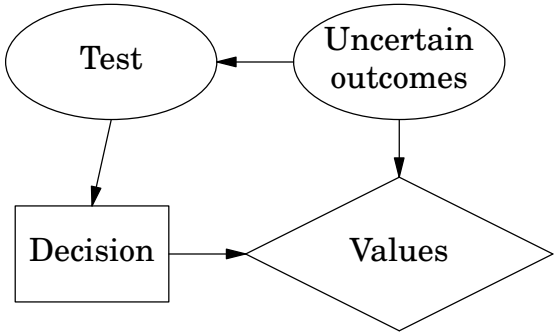


2. As no. 1, plus Value of Perfect Information. (Compare EV of 2. with the EV of 1.) (e.g. the clairyoyant)

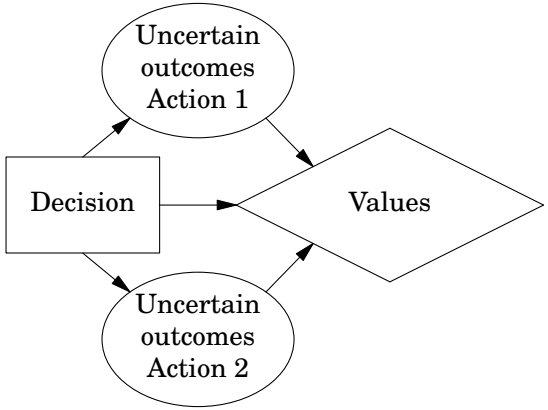


Types of Influence Diagrams

3. Value of Imperfect Information (Compare the EV of 3. — less than the EV of 2. — with the EV of 1. (e.g. test marketing, forecasting)

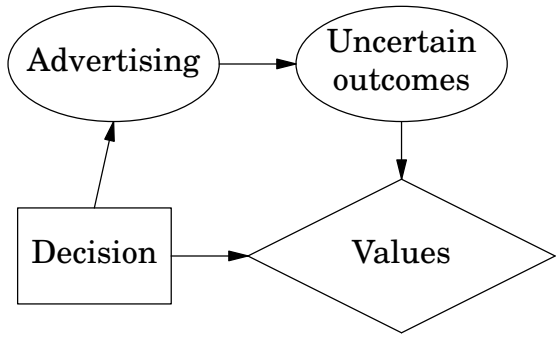


4. Probabilities are a function of the alternative chosen. (e.g. nuptial vows)

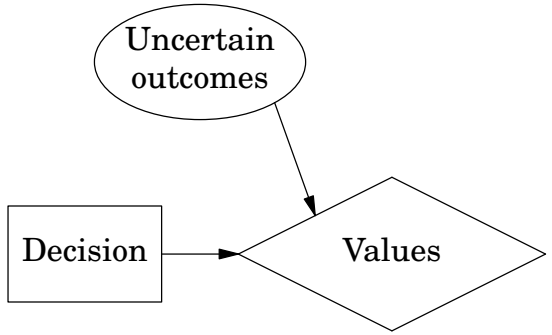


Types of Influence Diagrams (cont.)

5. Decision influences the probabilities.
(e.g. advertising)

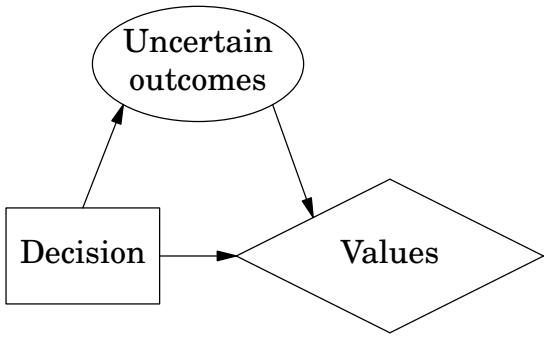


6. Insurance
(such as an umbrella)

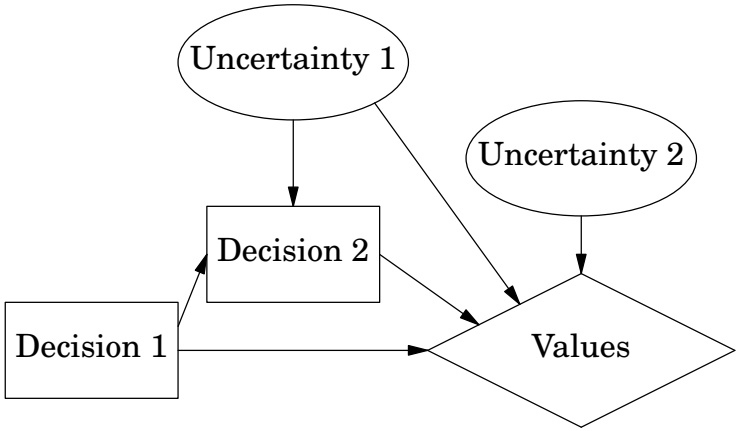


Types of Influence Diagrams (cont.)

7. Incentives: moral hazard with insurance (i.e. less care about locking up the house if 100% insured against theft.)



8. Two-stage decision (e.g. Pennzoil)



Decision Trees

A *decision tree* is a flow diagram that shows the logical structure of a decision problem. (With only one strategic player, it's the DMUU equivalent of the game tree with two or more strategic players.) It is a visual aid to lay out all the elements of a decision. It contains four elements:

- *Decision nodes,* □, which indicate all possible courses of action open to the decision maker;
- *Chance nodes,* ○, which show the intervening uncertain events and all their possible outcomes; i.e., Nature plays
- *Probabilities* for each possible outcome of a chance event; and
- *Payoffs,* which summarize the consequences of each possible combination of choice and chance.

Decision trees and Influence diagrams.

Trees structure the timing of the decisions and the revelation of the uncertainties.

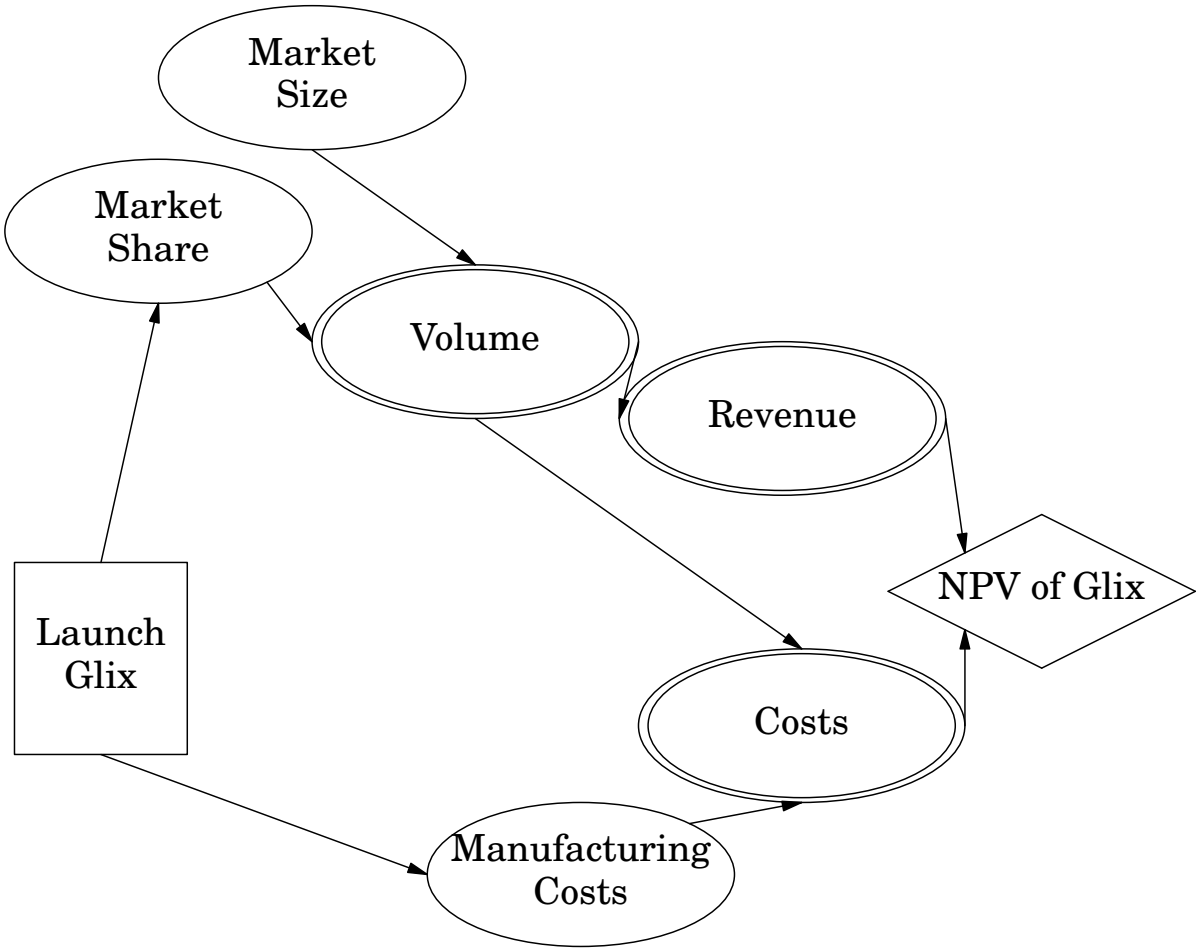
Diagrams structure the influence: on decisions, on values, on uncertainties, as well as structuring the timing.

The two can be effectively identical, with good software (such as Treeage's DATA or Palisade's Precision Tree for Excel).

Decision analysis forces you to think carefully about:

- the true nature of the decision problem;
- the role of chance; and
- the nature of the sequential interaction of decisions and chance events.

Influence Diagram



1.7 Probabilistic Evaluation

Deterministic uncertainty is important for identifying key variables but does not provide insight into the likelihood of any scenario.

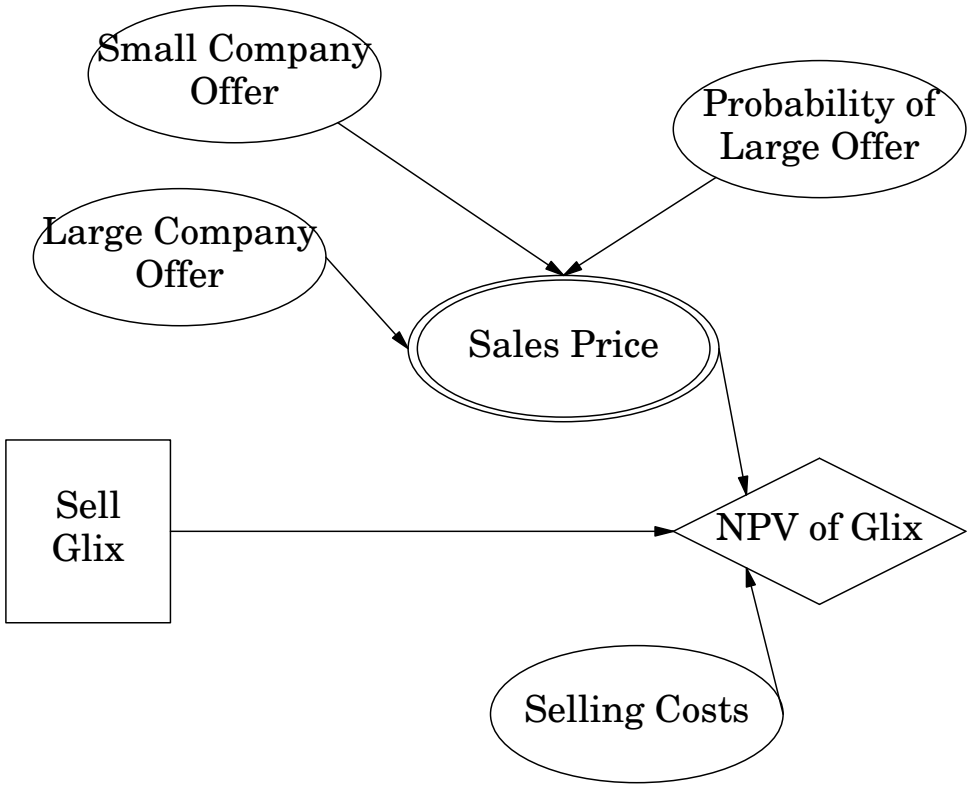
The cumulative probability distribution provides a graphical risk profile for the project or each alternative.

(This is more technical: see David C. Skinner, *Introduction to Decision Analysis* (Gainesville, Fl., 2nd. ed., 1999), pp. 112–113, 218–220.)

Another alternative? Selling the Glix project.

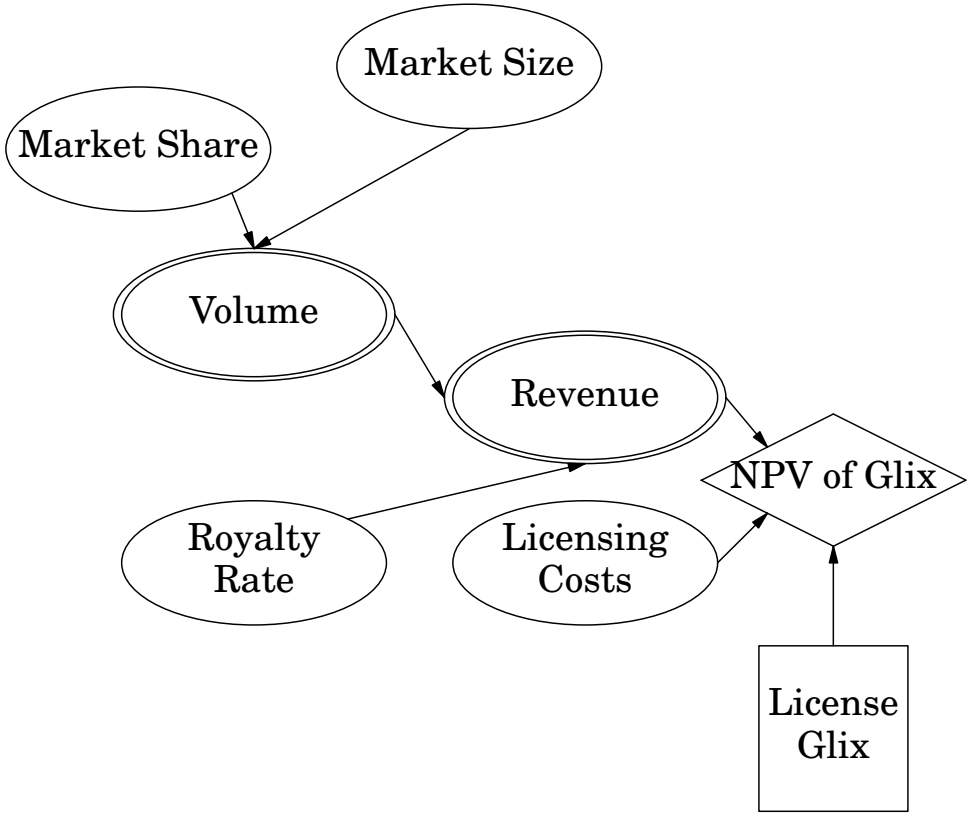
In addition to launching Glix, the company also wanted to evaluate the alternatives of selling and/or licensing the product.

The influence diagram for selling Glix to another company:

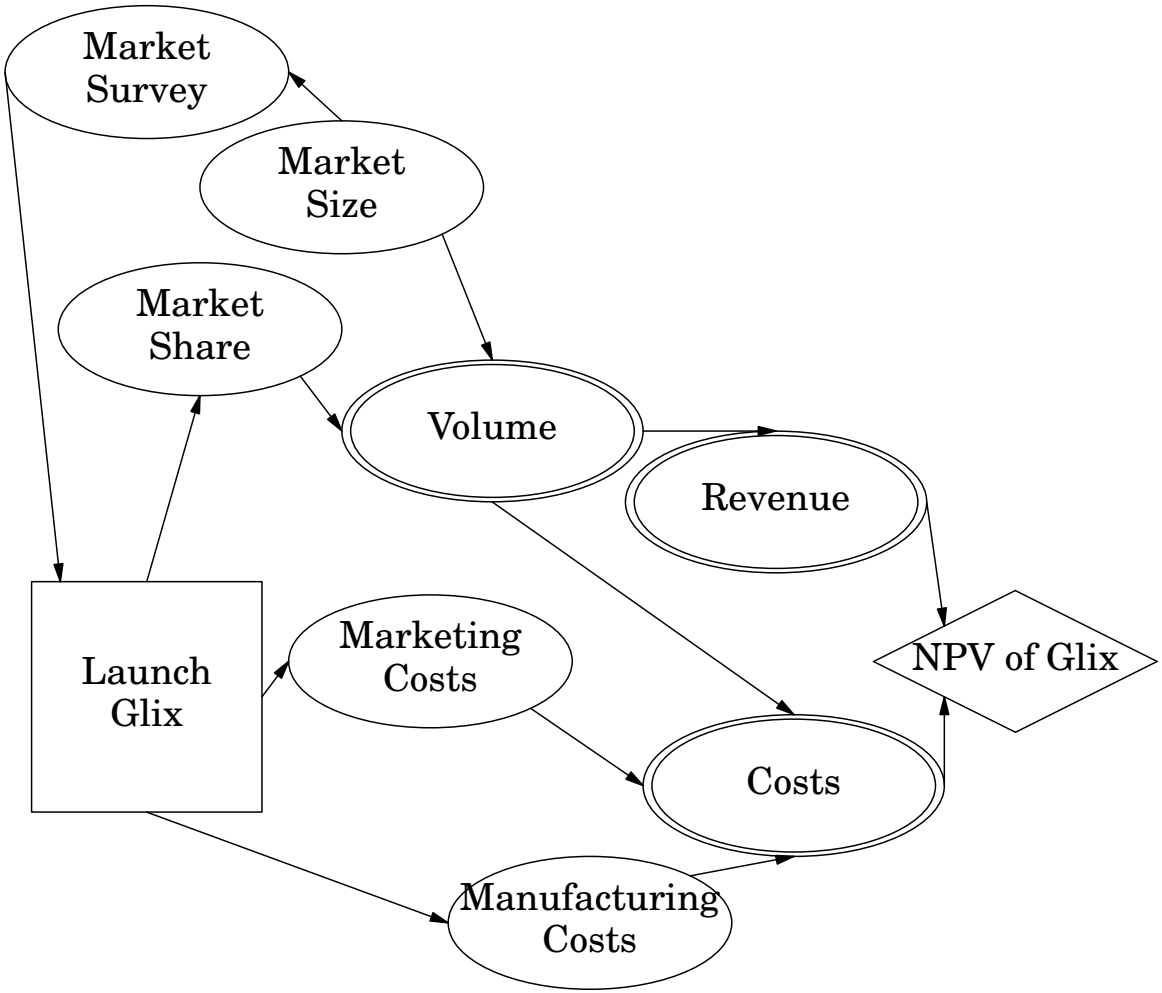


Or Licensing Glix:

The company could license Glix and receive royalties from the sales.



Survey Influence Diagram.



1.8 Laura's Case — The VPI

Laura could reduce uncertainty through *information gathering*:

- Laura could employ a market-research firm to test for the acceptance and demand for Retro.
- If totally reliable (no errors), then
  - if "Retro is definitely a goer", then a return of $240,000, less costs
  - if the Trial indicates Retro is a fizzer, then choose a net return of $200,000 with Trad, less costs

Laura has two decisions to make:

1. Whether or not to Trial, which is related to the cost of the Trial.

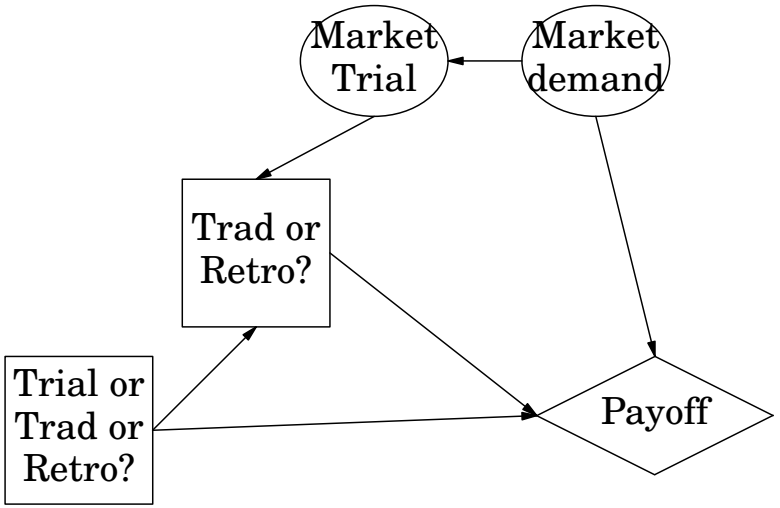
   For a given cost, should she Trial?

   If not, then the decision is as before: Trad or Retro?
2. If she buys the Trial, what's the most she should pay for it?

   To answer this, we need to examine her best choice with the Trial: Trad or Retro?

The *value of information* is the difference between Laura's expected returns with the Trial and without the Trial.

If the Trial is 100% reliable, then this is the *Value of Perfect Information* (VPI):



The arrow from the Market Trial chance node to Laura's second decision represents the information (perfect or not) that she receives from the Trial.

That information in turn is influenced (perfectly or not) by the actual Market Demand.

What Laura would like to know is what a specific piece of information implies for the eventual market demand for Retro, that is,

Probability (Retro is a Goer, given that Trial says so)

With perfect information, this probability is 1.

References about Influence Diagrams

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