

Value-of-information when making risk-based decisions

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[#RISKWARENESSWEEK2019](#)

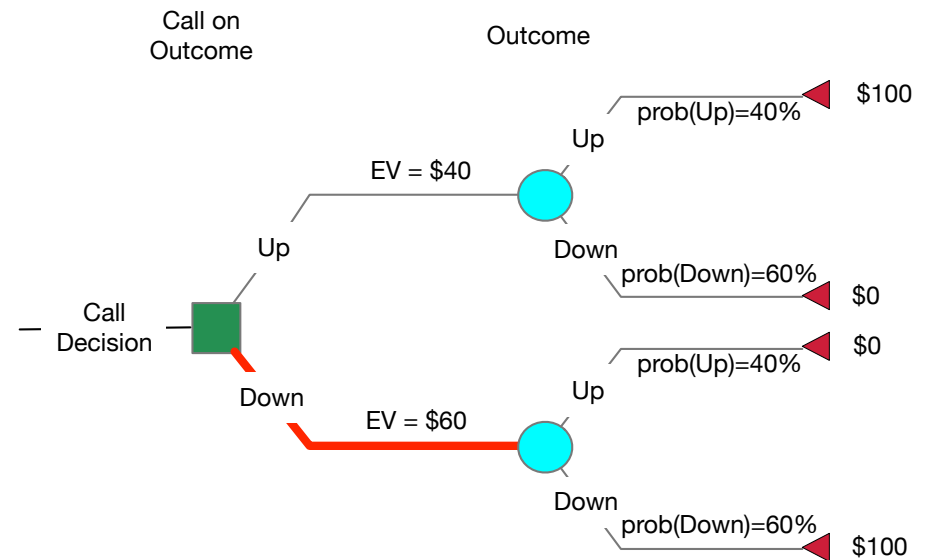


Introduction to Value of Information

How much would you pay to know the best path forward?

Every decision we consider faces the uncertainty that outcomes won't match our preferences

- You win a bid to acquire a future payoff by taking a gamble
- Your correct call on the outcome of a tossed tack determines which payoff you receive
 - Tack up = \$100
 - Tack down = \$0



The Call Decision that maximizes expected value is “Down”

The Clairvoyant predicts the future with certainty, ensuring that you will win

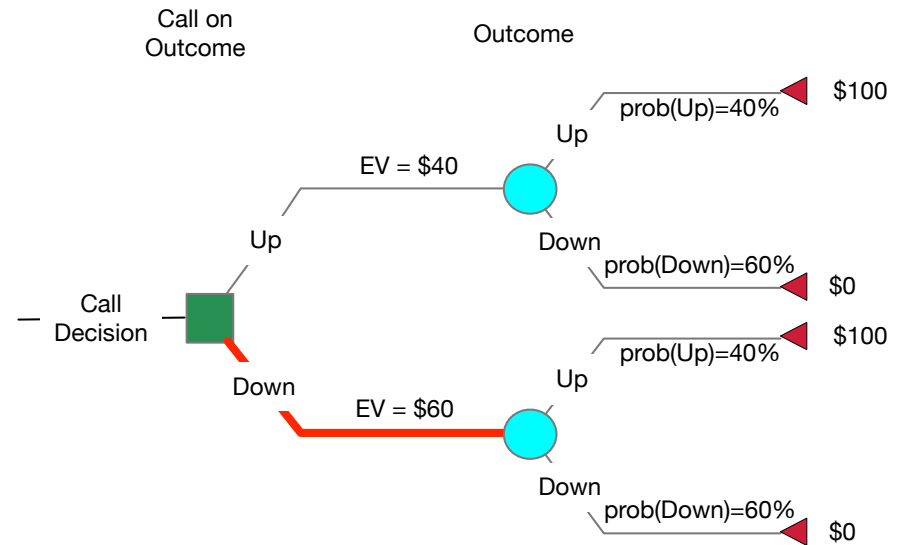
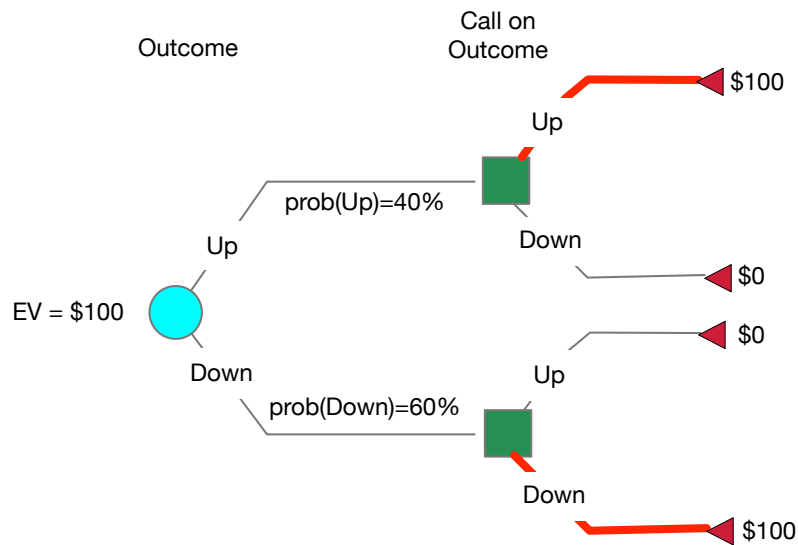


I can tell you the outcome

...for a price.

How much are you willing to pay?

We should consider how much we would be willing to pay to know the outcome before making a decision



Value of Information = Value of Knowing Beforehand – Decision Maximizing Expected Value

Value of Information = \$100 – \$60

Value of Information = **\$40**

Case Study: Freemark Abbey Winery

Did you pay too much for that information?

A storm was brewing at Freemark Abbey Winery

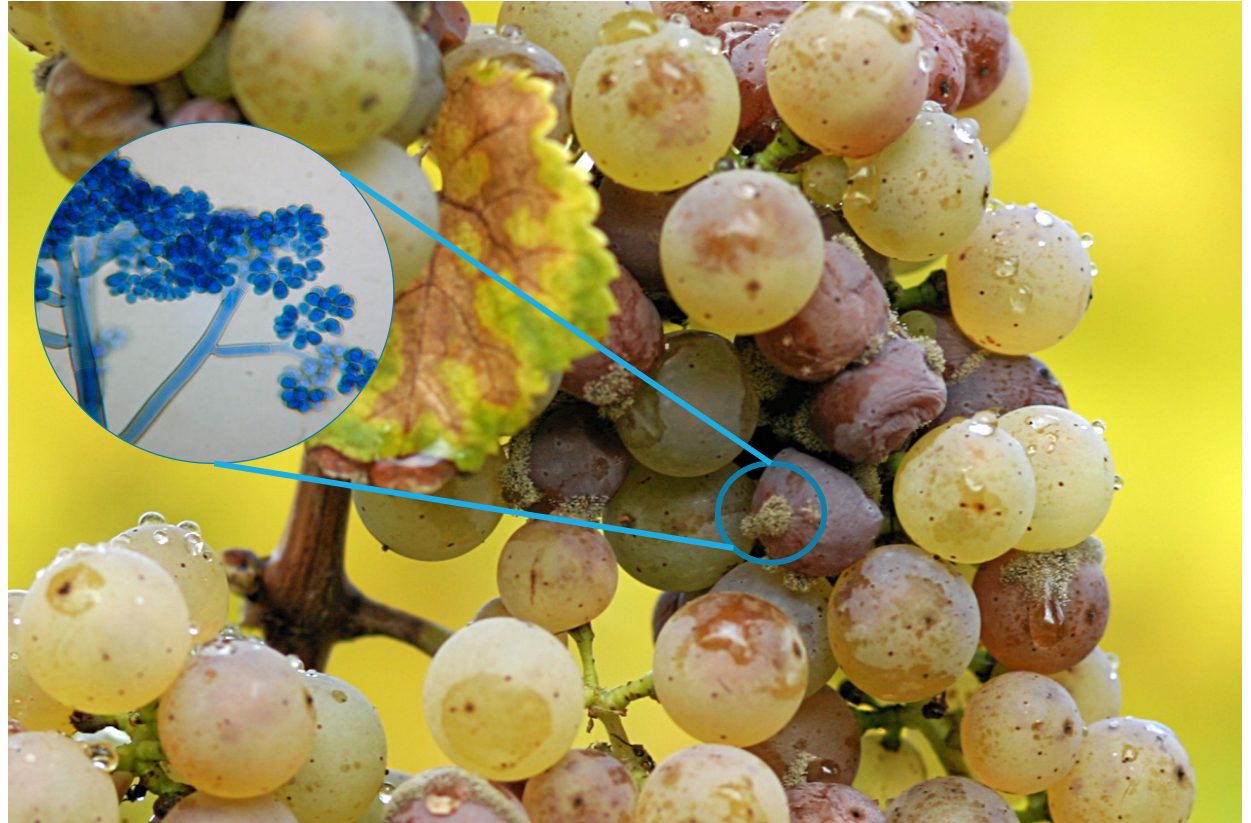
- In Sept 1976, a storm approached the Nappa Valley just before harvest.
- The additional water can ruin crops.
- William Jaeger assessed the probability of rain at 50%.



Photo by [Tim Mossholder](#) on [Unsplash](#)

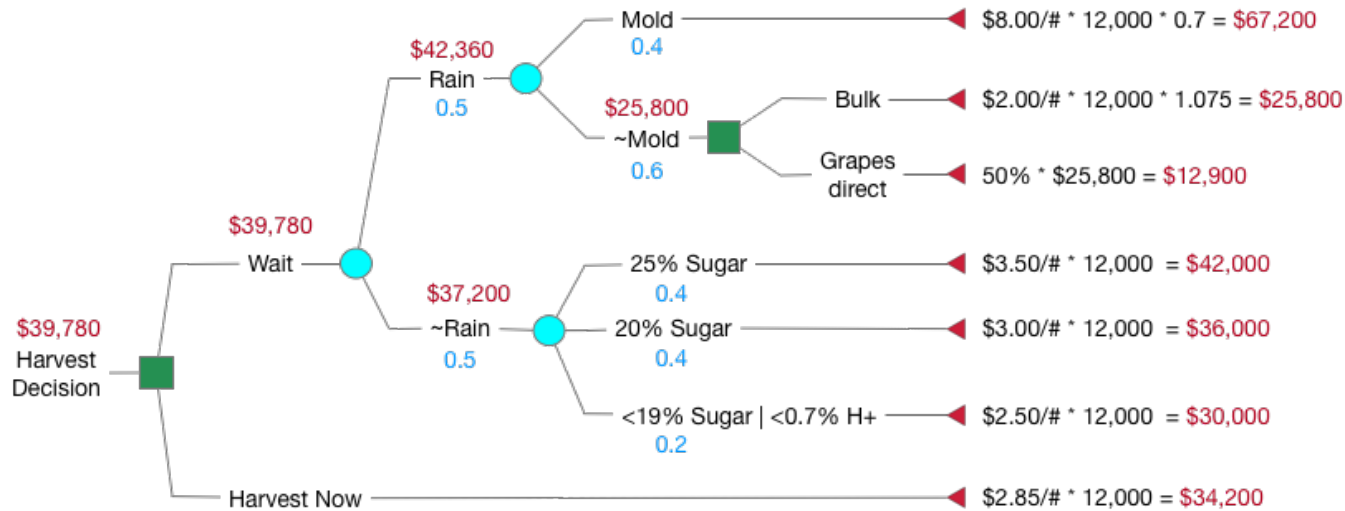
The “noble rot” can transform Riesling into gold

- A warm, light rain can trigger growth of mold *botrytis cinerea*.
- *B. cinerea* can result in a luscious, complex sweet wine, highly prized by connoisseurs, 2.8x a normal Riesling.
- If it rains, the probability of the mold forming is 40%.
- Would you harvest or wait?



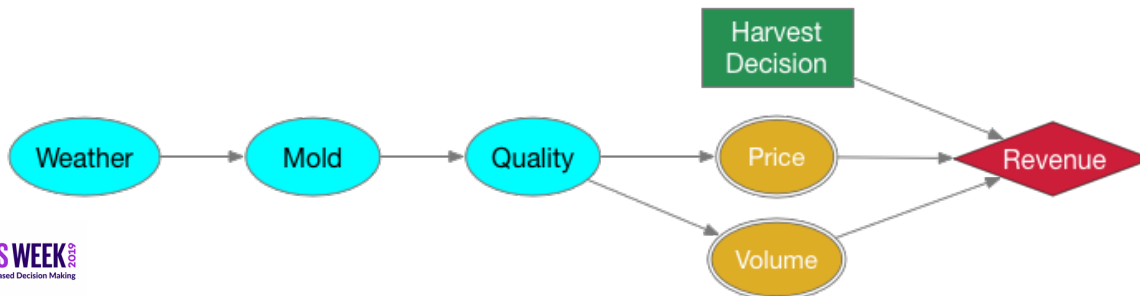
https://en.wikipedia.org/wiki/Botrytis_cinerea#/media/File:Botrytis_riesling.jpg

An influence diagram and decision tree help to clarify the value of the imminent decision alternatives.



If you could acquire perfect information about just one variable, which one would you choose?

How much should you be willing to pay?



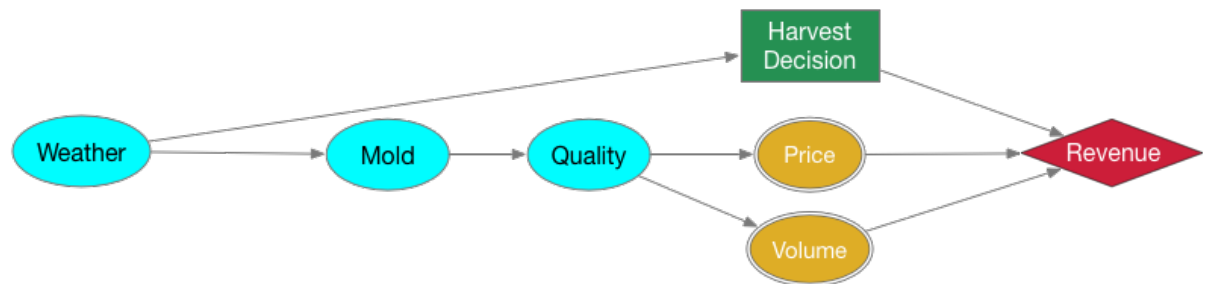
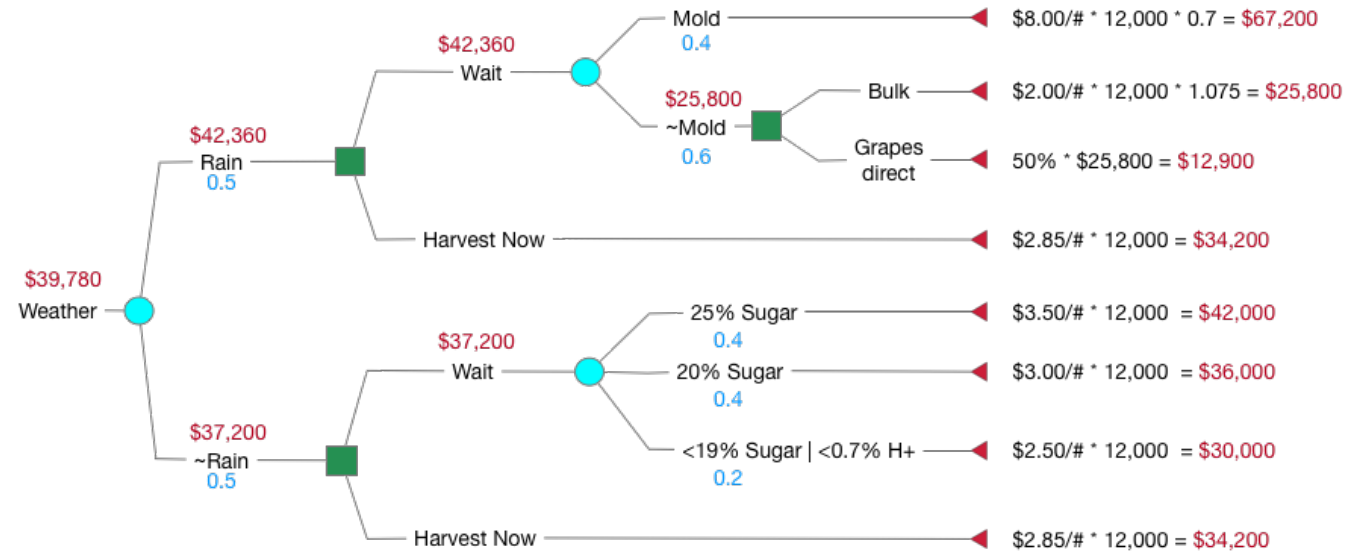
Should the winery pay for a perfect forecast?

- Reorder the decision tree such that you know the outcome of the weather before harvesting.

- VOI = Value of Knowing Beforehand – Decision Maximizing Value

$$\text{VOI} = \$39.8\text{K} - \$39.8\text{K} = \$0$$

- Regardless of knowing the rain outcome, it's better to wait.



Learn to drink information responsibly

Paying for information often makes us feel good, but it may offer no additional effective decision guidance.



Photo by [Nadine Shaabana](#) on [Unsplash](#)

VOI with continuous variables

Optional text

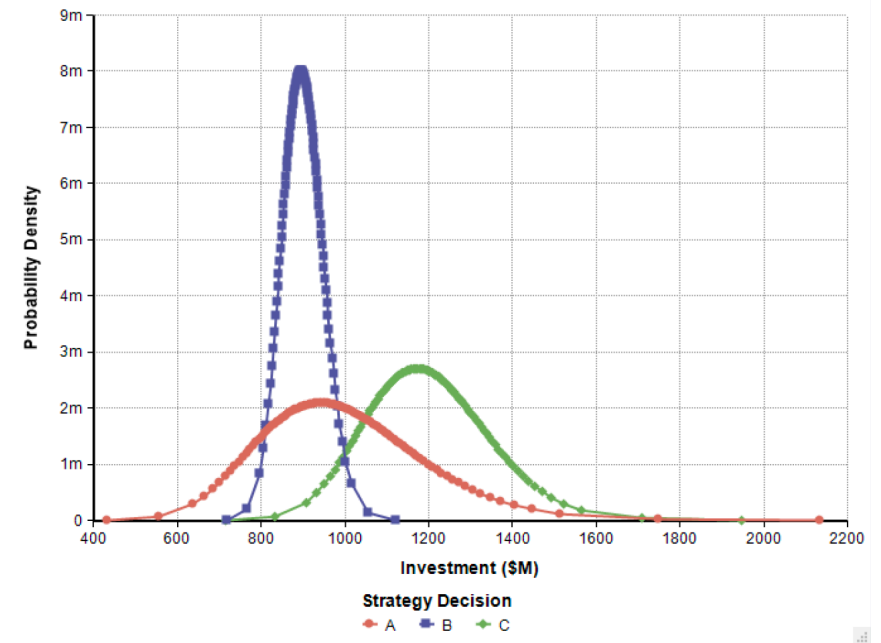
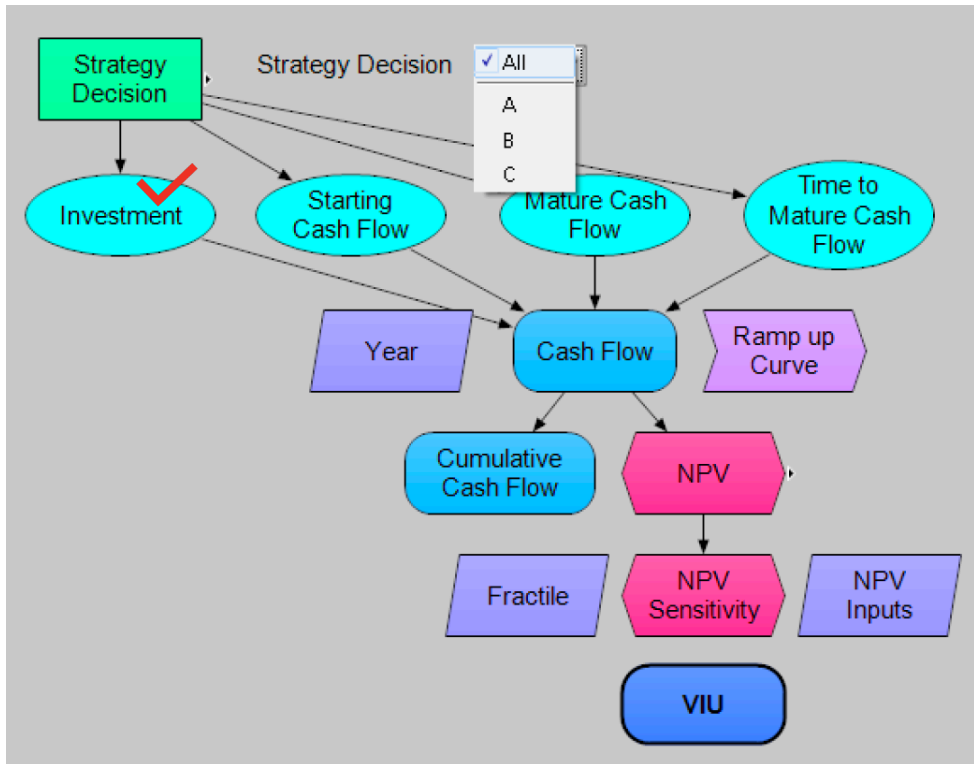
Not all uncertainties that we face are discrete or even obvious

- The value of many business decisions are affected by uncertainties that are continuous in nature.
- Sometimes there are so many uncertainties that it's difficult to know which one we should prioritize for research efforts.
- These uncertainties can often be very skewed as well as multimodal.
- It's difficult to find proper discrete representations that preserve the characteristics of the distributions as well as not leading to a overly complex decision tree representations.



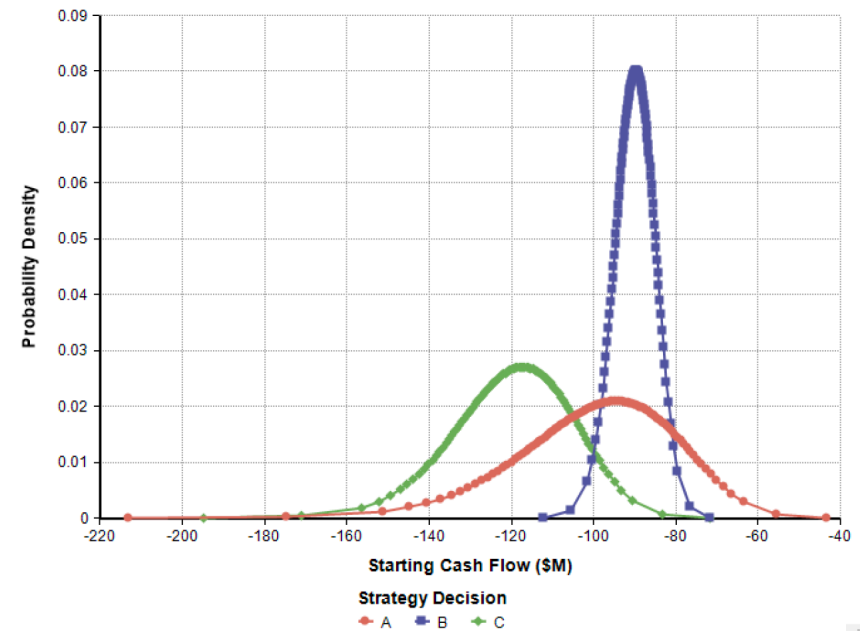
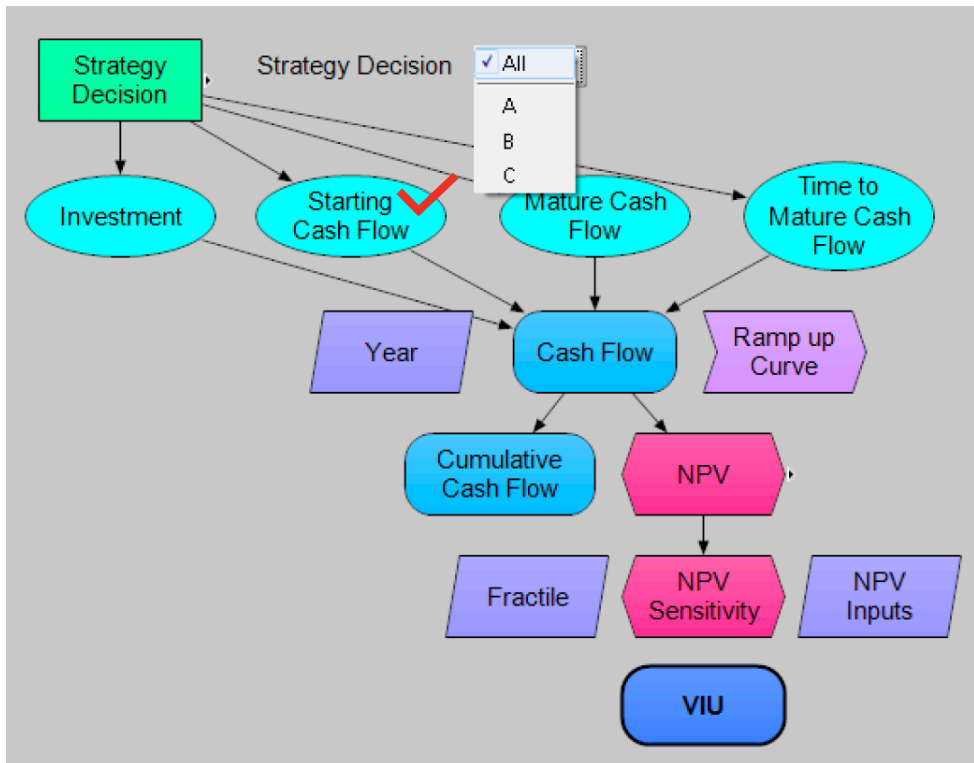
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Consider a business case with four key uncertainties, each conditional on a selected strategic alternative.



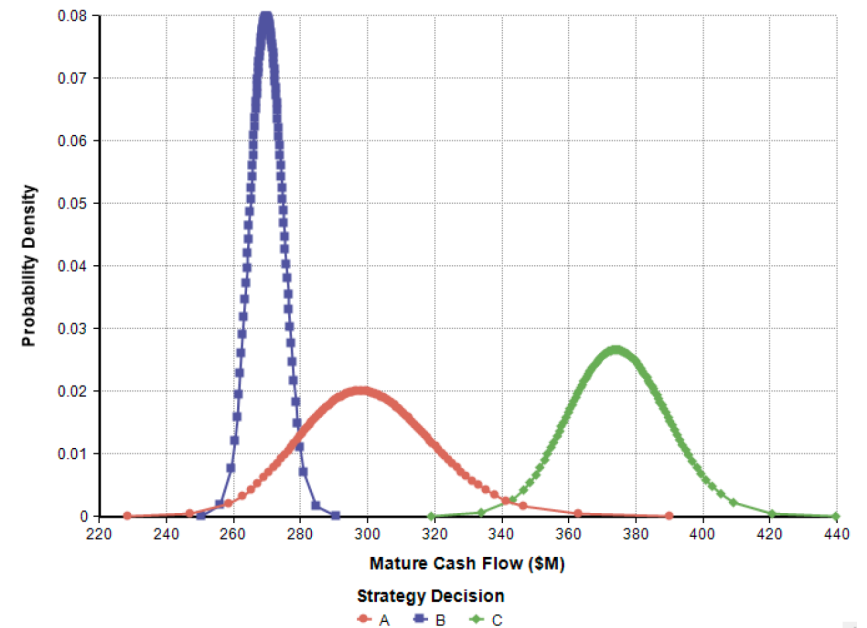
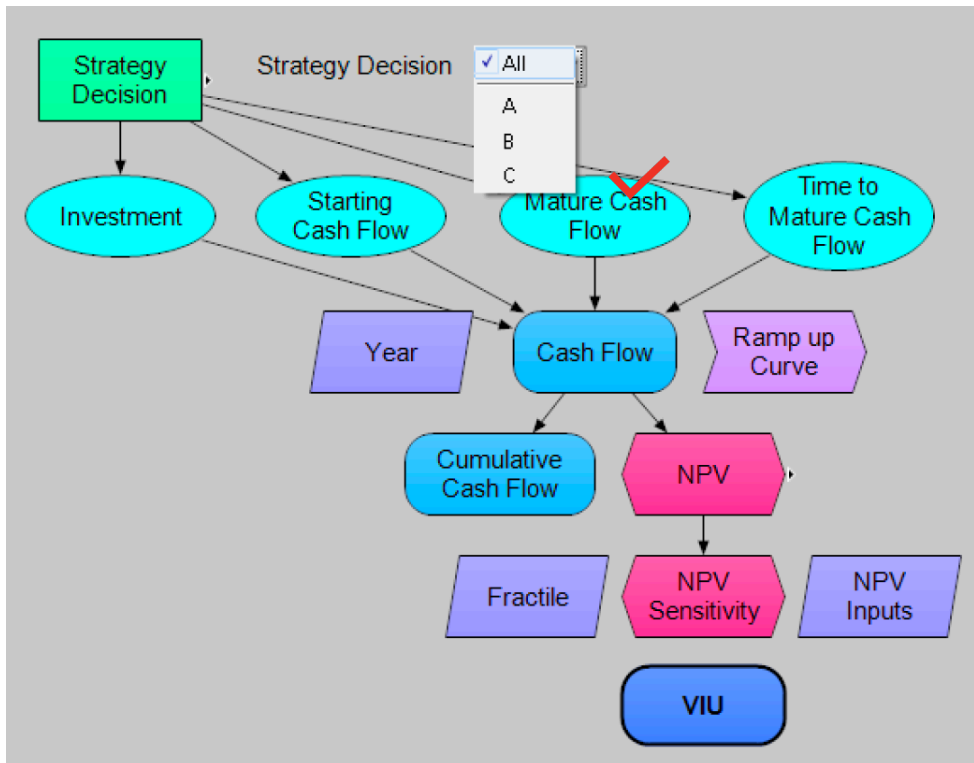
Investment

Consider a business case with four key uncertainties, each conditional on a selected strategic alternative.



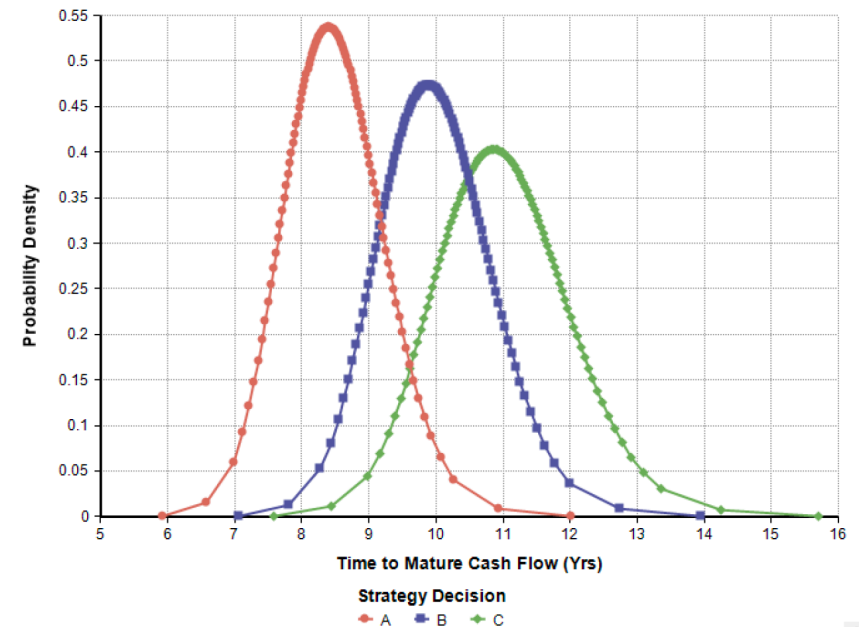
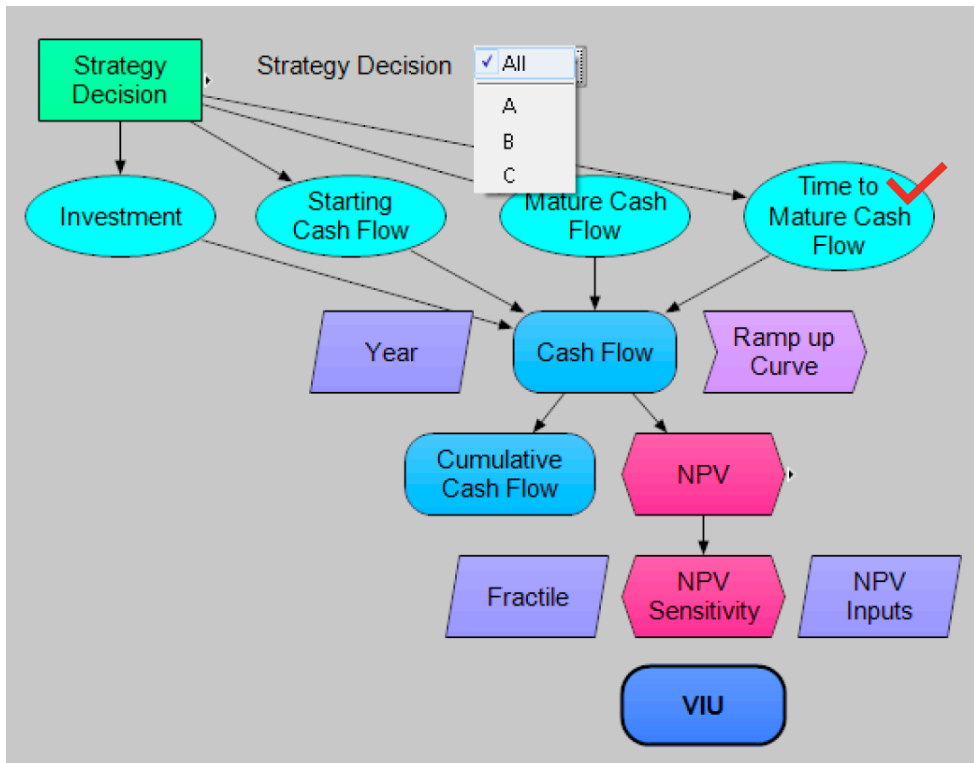
Starting Cash Flow

Consider a business case with four key uncertainties, each conditional on a selected strategic alternative.



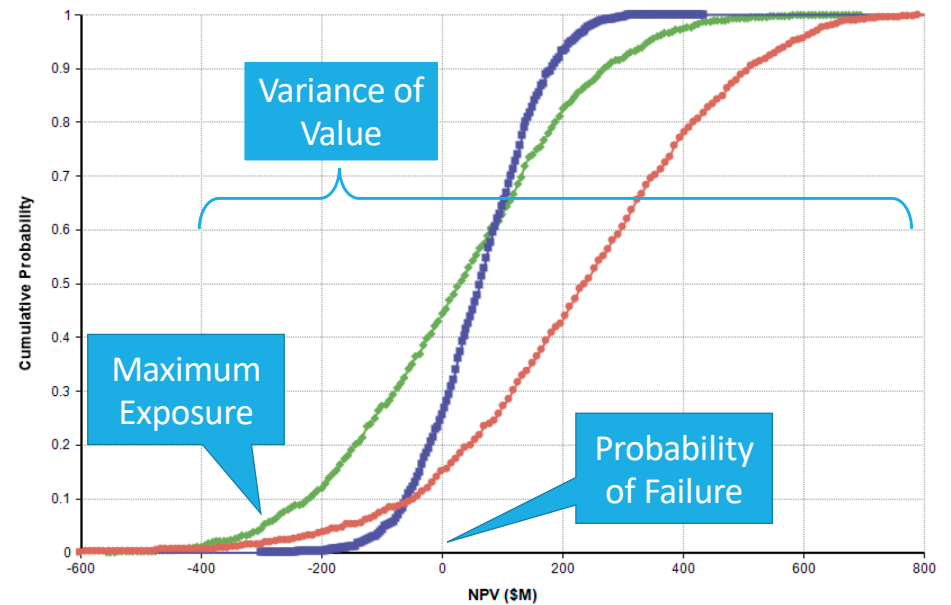
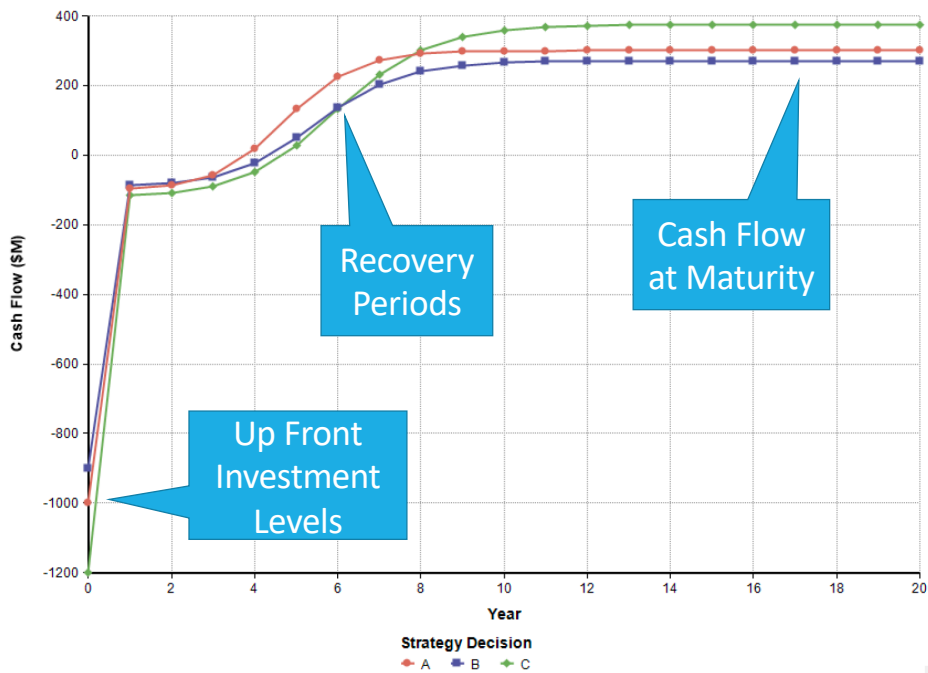
Mature Cash Flow

Consider a business case with four key uncertainties, each conditional on a selected strategic alternative.



Time to Mature Cash Flow

Each strategy presents us with several tradeoffs to balance

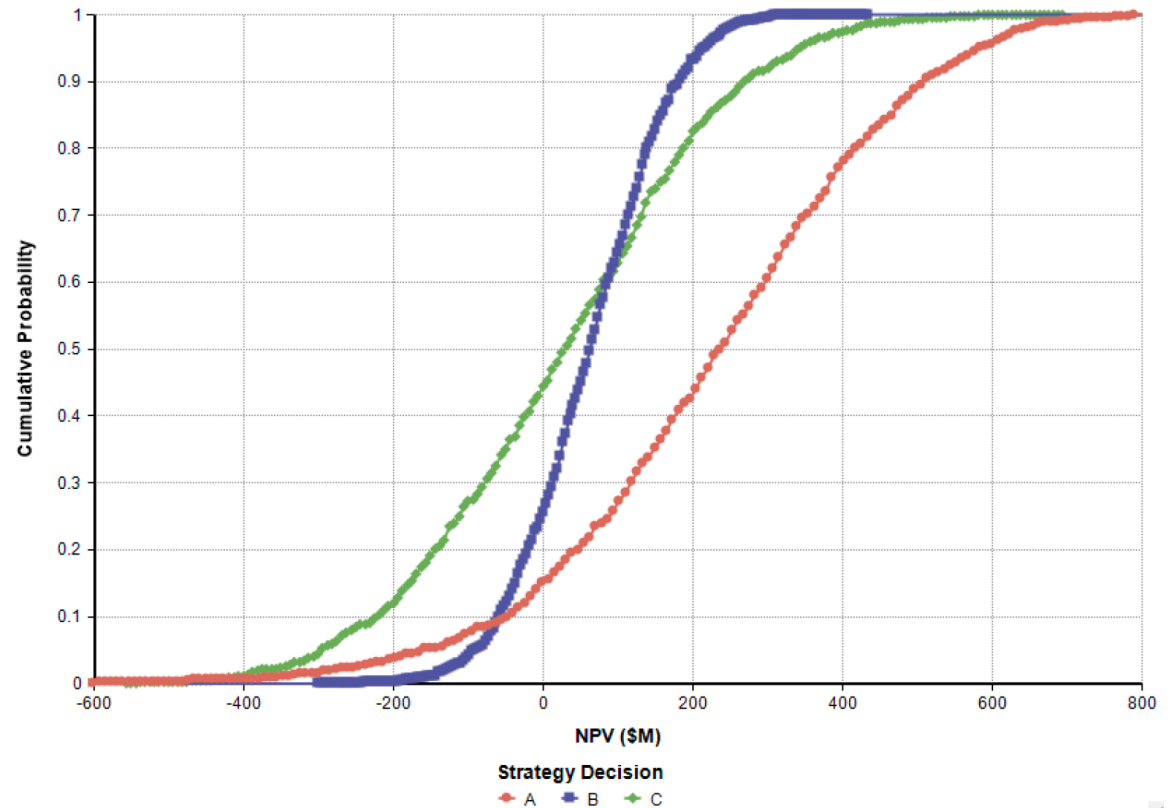


Mean Value of NPV (\$M)	
Strategy Decision	Totals
A	227
B	60.82
C	24.37

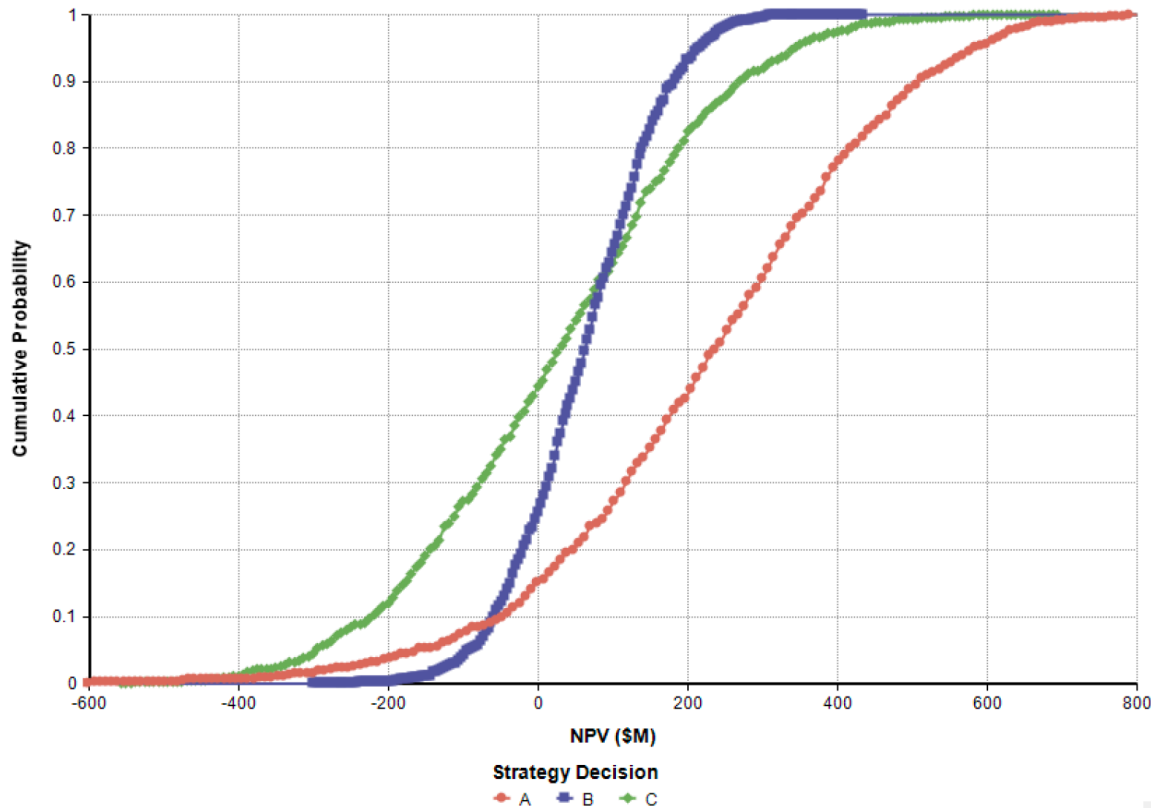
Expected Values

Classical finance theory presents us with a dilemma

- Prefer strategies with the highest expected value
- Prefer strategies with the least variance
- Prefer strategies that are stochastically or strictly dominant over alternatives

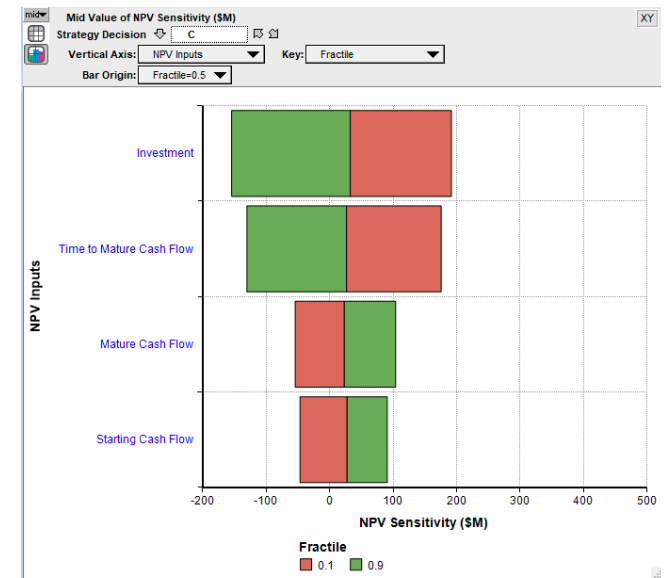
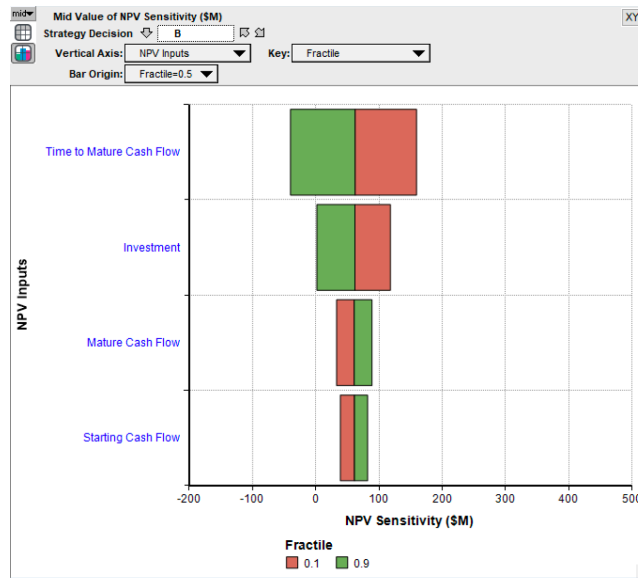
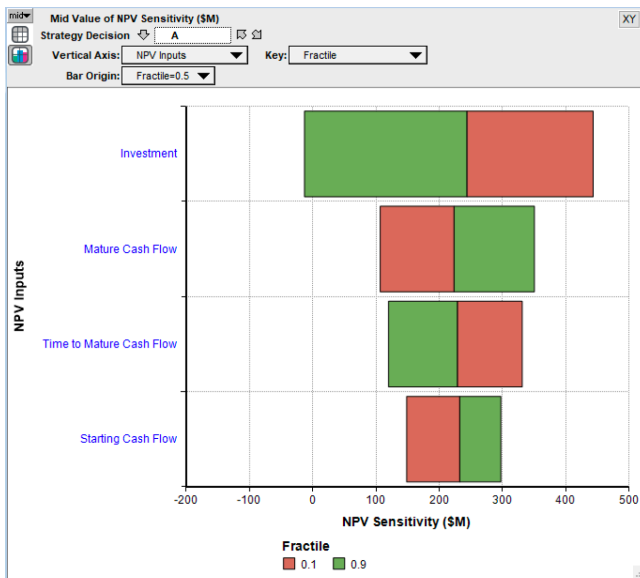


Selecting Strategy A presents trade-offs for rejecting the next best Strategy B



- Which strategy would you prefer?
- How would you prioritize your search to improve the precision of your value measure?
- At most, how much should you be willing to pay to improve the precision?

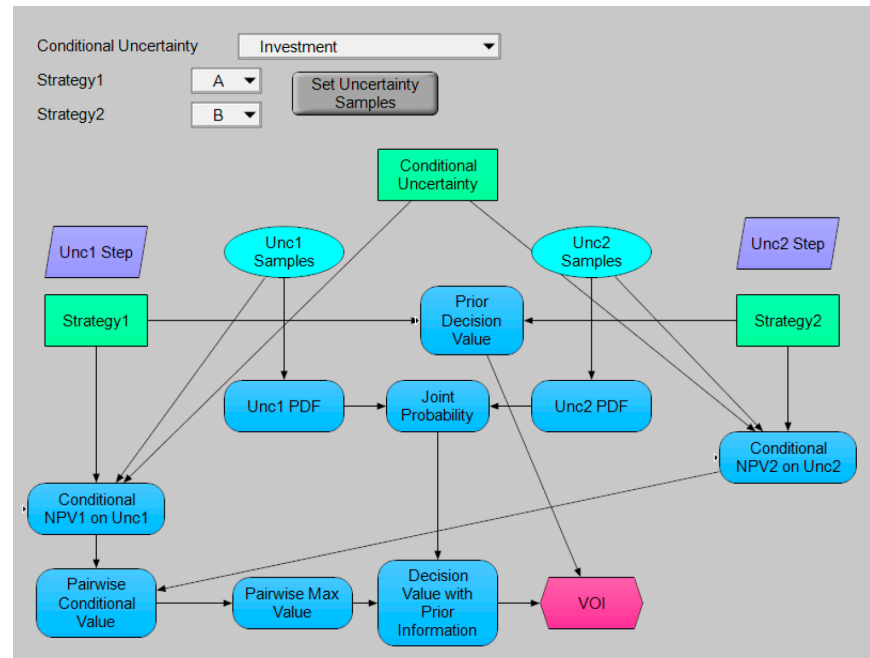
Sensitivity analysis shows us which uncertainties most likely will cause us to regret taking the strategy with best average value



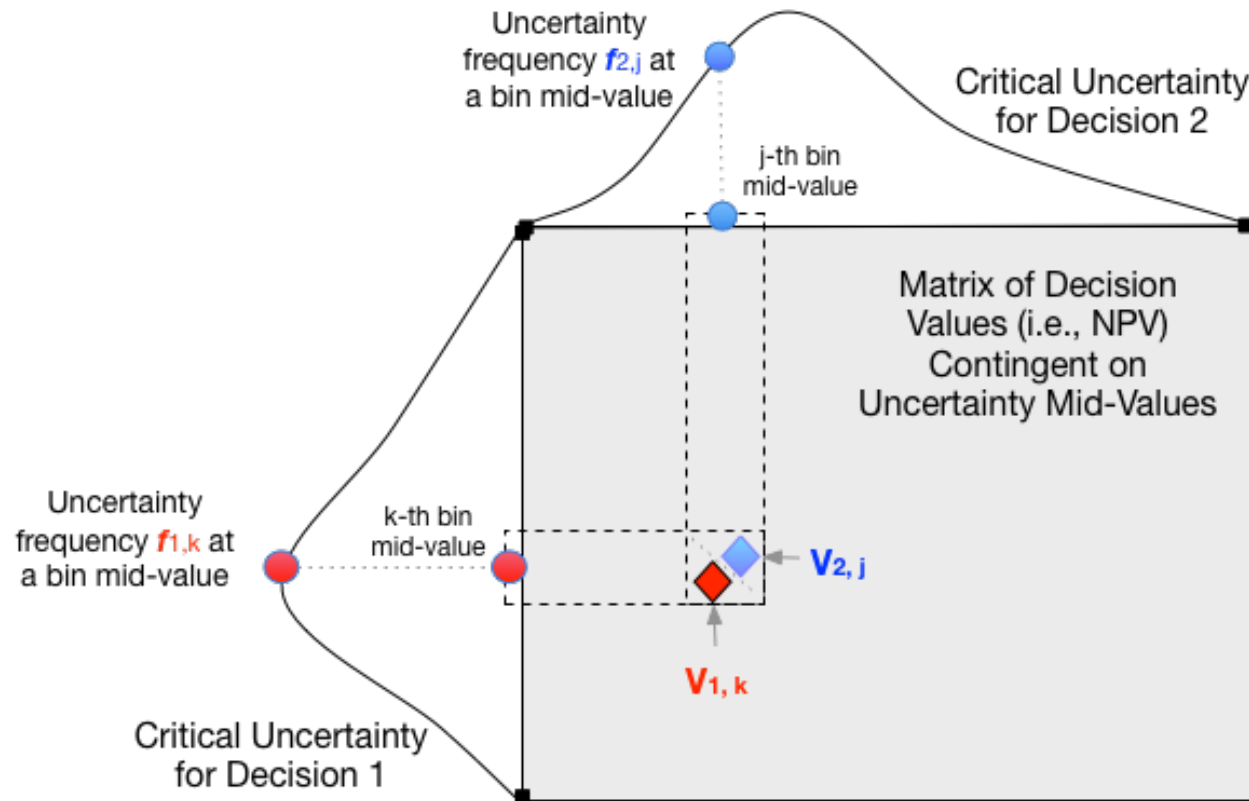
Investment is a critical uncertainty between A and B, the two strategies with the highest average value.

Value of Information - the rational maximum budget to improve the quality of information that reduces the ambiguity of the decision

$$\text{VOI} = \text{Value of Knowing Beforehand} - \text{Decision Maximizing Expected Value}$$

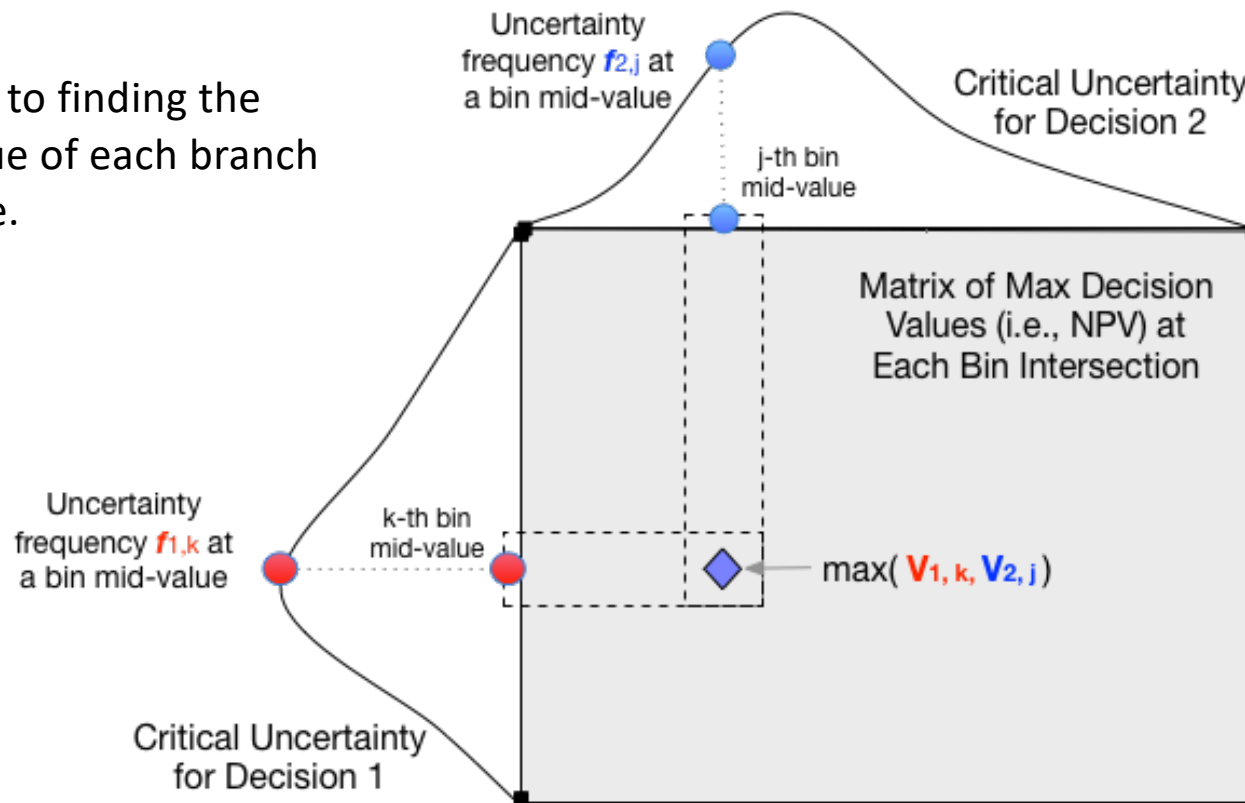


Find all combinations of conditional decision value on all uncertainty bins



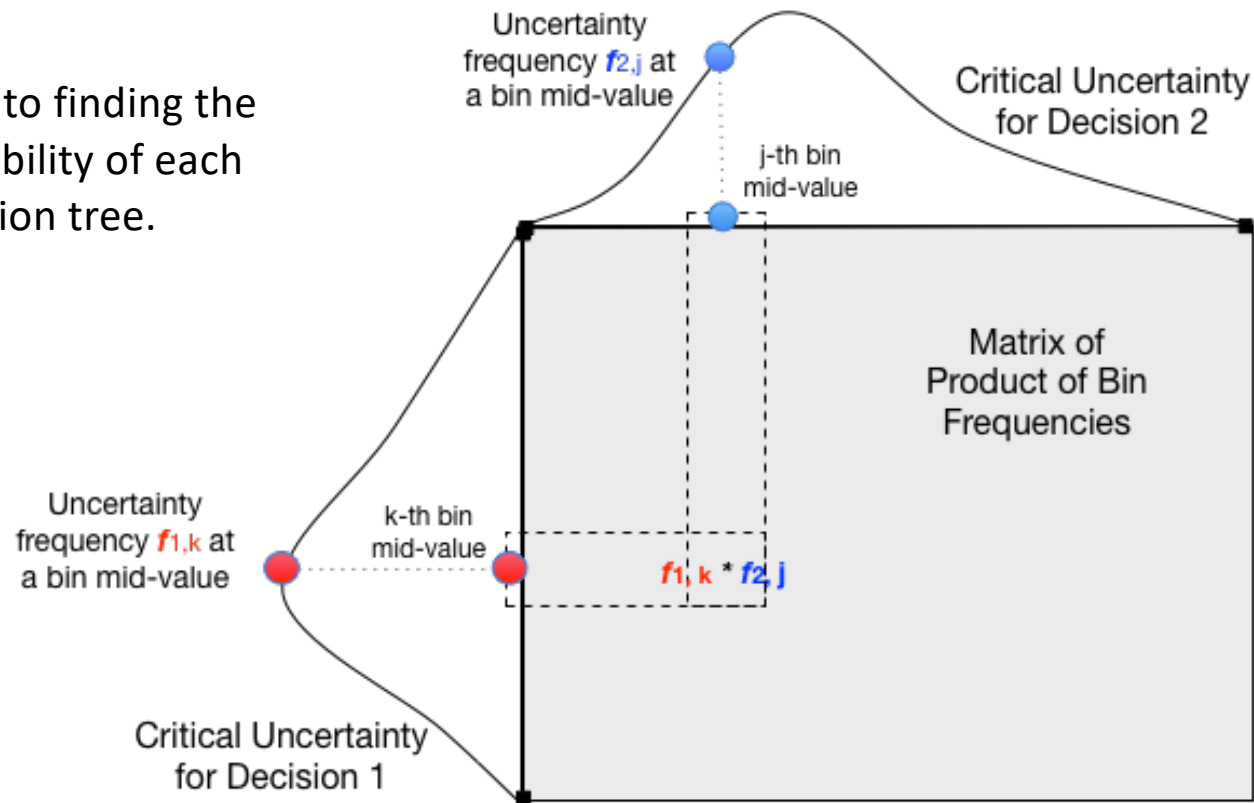
Find the pairwise max value of each combination.

This is equivalent to finding the max decision value of each branch on a decision tree.



Find the joint frequency of each bin.

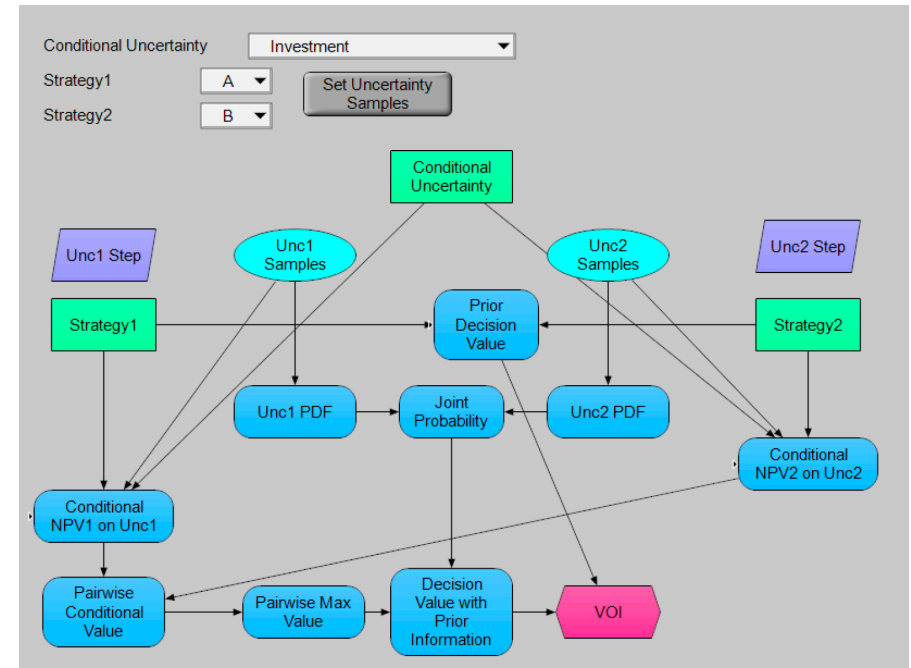
This is equivalent to finding the conditional probability of each branch on a decision tree.



Decision value with prior information → Sum over product of joint probability of bin frequencies with pairwise max values

$$\begin{aligned}
 \text{VOI} &= \text{Value of Knowing Beforehand} - \text{Decision Maximizing Expected Value} \\
 \text{VOI} &= \text{Value of Knowing Beforehand} - \text{Max}(227\text{M}, 60.8\text{M}) \\
 &= \$250\text{M} - \$227\text{M} \\
 &= \$23\text{M}
 \end{aligned}$$

The rational maximum budget to determine the investment requirements to choose clearly between A and B





Thank You!