The Battle Against Bayesian Amnesia*

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Abstract

"The chance of success (COS) on this prospect is 20%, but if we shoot 3-D seismic, it will go up to about 40%. The COS on that prospect is also 20%. If we see an AVO anomaly, it will go up to about 50%; if we don't, it will stay at 20%." Comments like these are common in the upstream energy industry, even among people who have experience in value-of-information (VOI) analysis. Unfortunately, the first comment is extremely misleading and the second is mathematically impossible. There are certain laws of probability that simply must be obeyed.

When acquiring seismic or interpreting a direct hydrocarbon indicator (DHI), many companies completely forget about their previous assessments of the COS for a prospect. This results in over-estimating COS and, therefore, under-performing relative to prediction. The confusion is exacerbated when the new information is expected to yield insights on several different uncertainties and/or the company plans to acquire more than one type of information to help with a single uncertainty.

This paper discusses several examples of scenarios like these, and how some basic (and not-so-basic) Bayesian decision trees can help people to see how to revise their uncertainty assessments appropriately in the wake of new data.

Decision Strategies

The Battle Against Bayesian Amnesia

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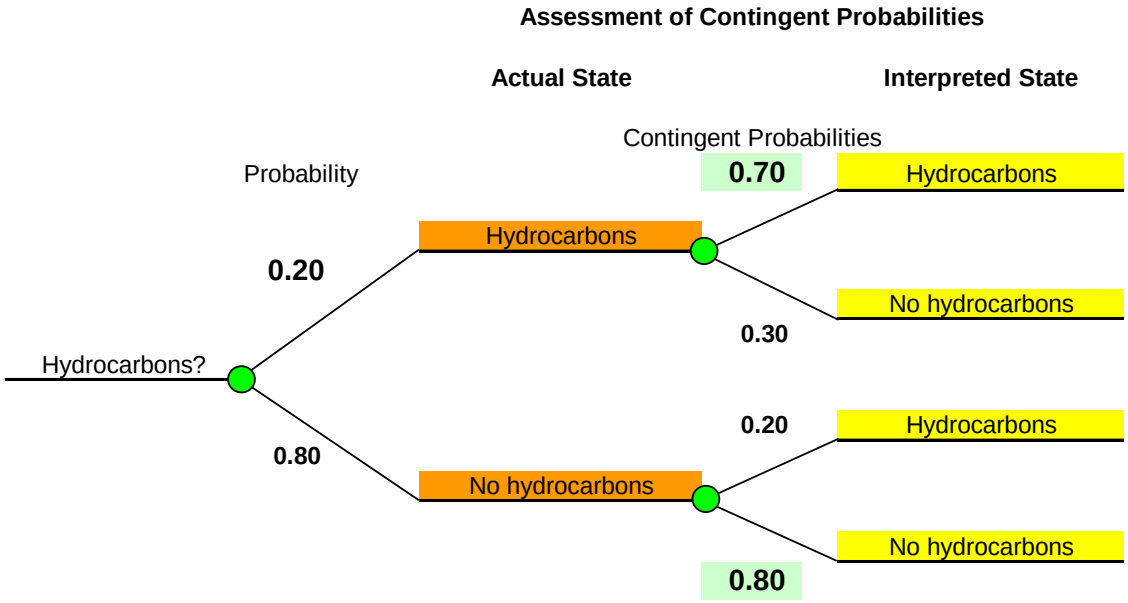
Heard around the Exploration Department

- "If we see an AVO anomaly, the COS will go up to 50%; if we don't see one, it will stay at 20%"
- "This prospect has a beautiful AVO anomaly over it. The COS is 90%"
- "The COS on this prospect is 20%, but if we shoot seismic, we can get it up to about 40%"

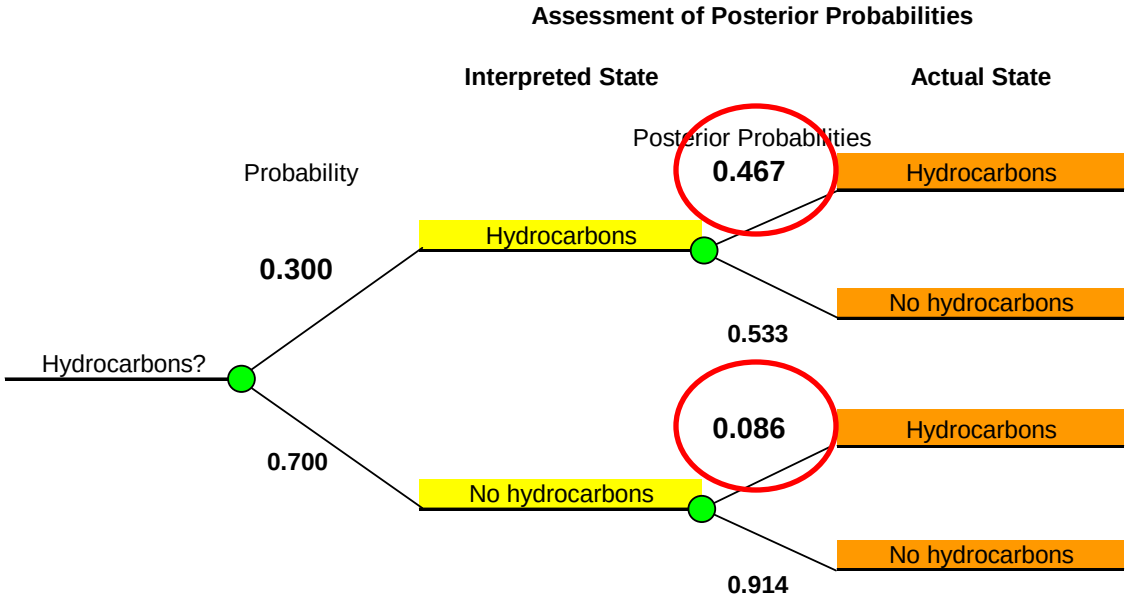
Bayes's Law (translated into Oil Patch from the original statistical jargon)

- You start with what's in the ground; what is the probability that it is actually there?
  - Given that it ***is*** there, what is the probability that our new information will enable us to ***correctly*** interpret that it ***is*** there?
  - Given that it is ***not*** there, what is the probability that our new information will enable us to ***correctly*** interpret that it is ***not*** there?
- From these probabilities we can derive:
  - The probability that we will ***interpret*** that it is there
  - If we ***interpret*** that it ***is*** there, the probability that it ***is actually*** there
  - If we ***interpret*** that it is ***not*** there, the probability that it ***is actually*** there anyway

Bayesian Amnesia #1



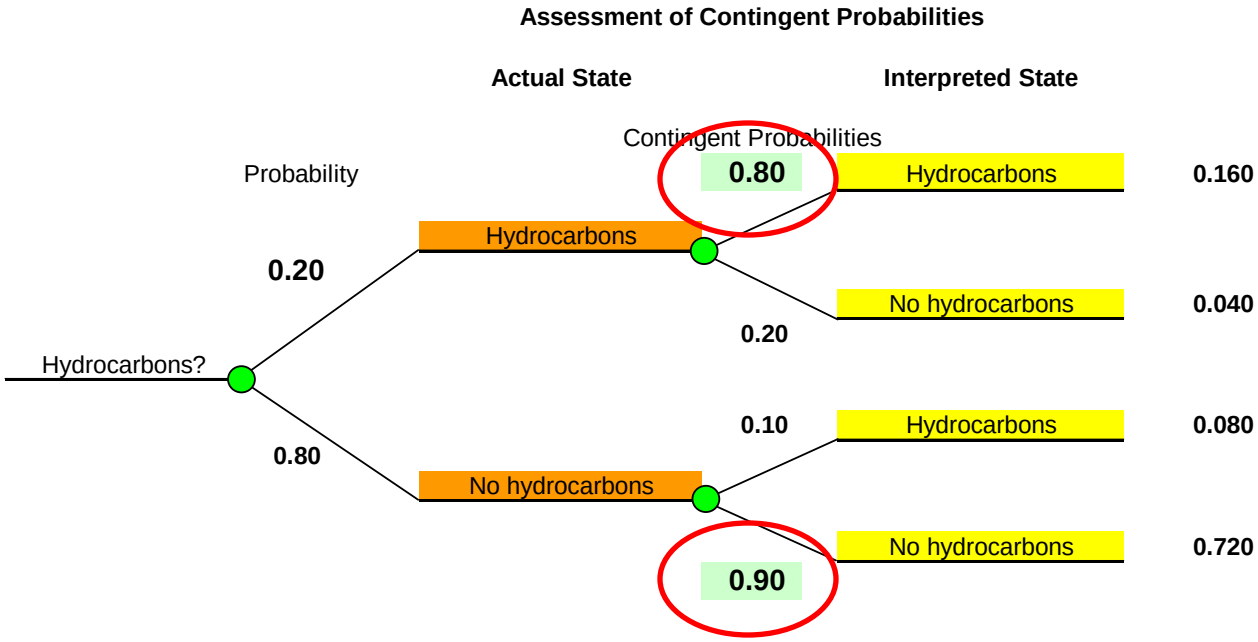
"If we see an AVO anomaly, the COS will go up to 50%; if we don't see one, it will stay at 20%"



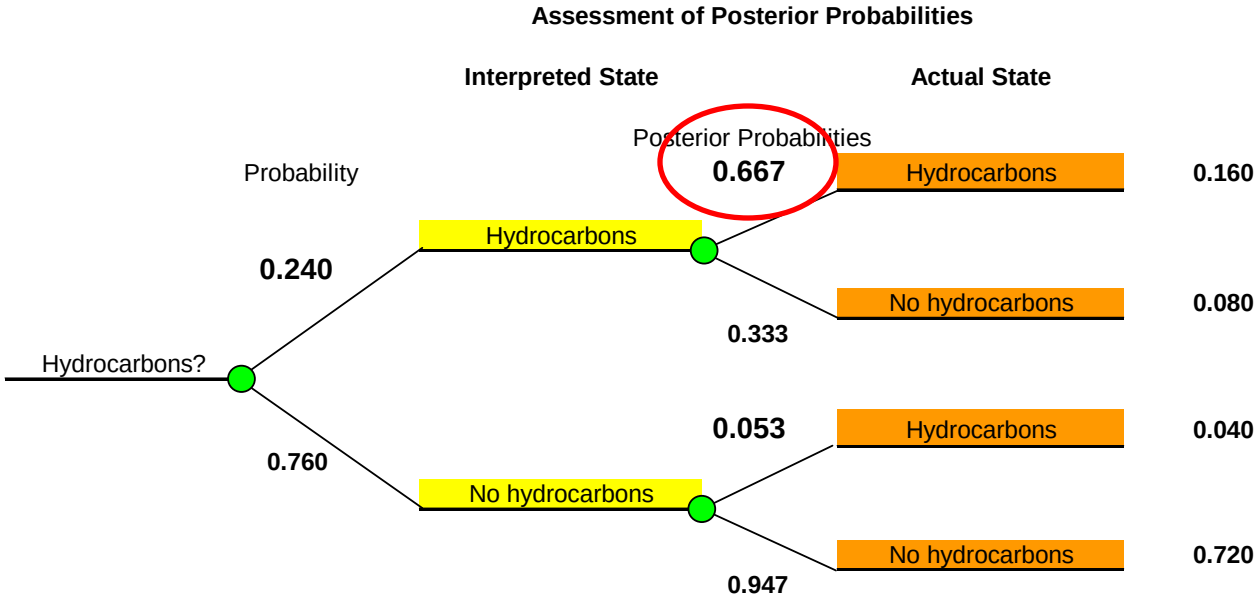
Bayesian Amnesia #2

- "This prospect has a beautiful AVO anomaly over it. The COS is 90%"
- When people see a DHI, they tend to forget about their analysis on the four risk elements
- Many companies directly assign COS factors depending on the quality of the DHI
  - A high-quality bright spot or AVO anomaly may be assigned a 90% COS

Bayesian amnesia #2



Even a highly reliable DHI is unlikely to get the COS up to 90%



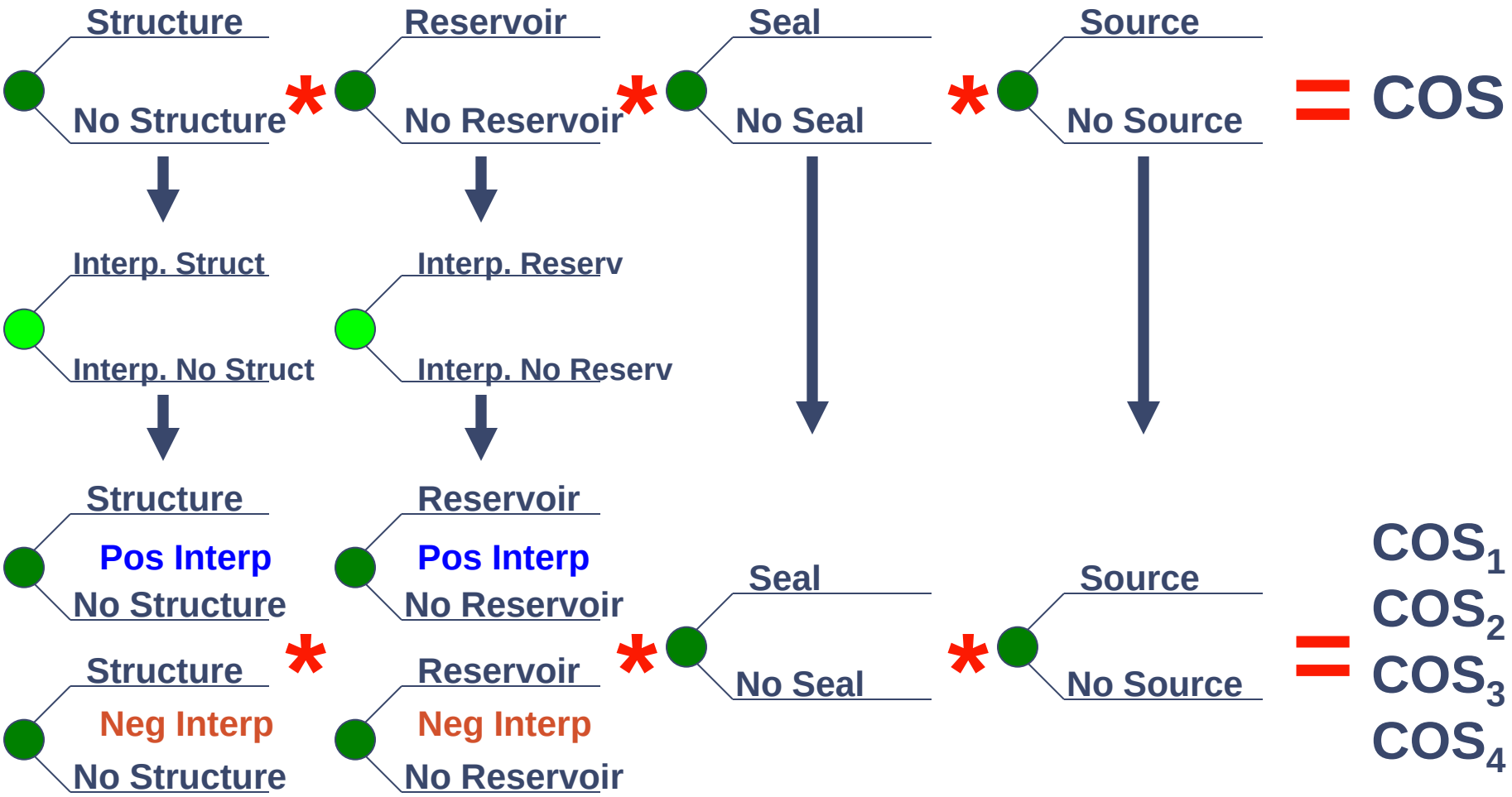
A couple of “difficult to accept” concepts

- The presence or absence of an AVO anomaly tells you ***nothing*** about the reliability of your data.
- Only ***after*** interpreting your AVO data may you use the presence or absence of a DHI response/anomaly to modify your probability of success.

Consider the acquisition of seismic data over a prospect

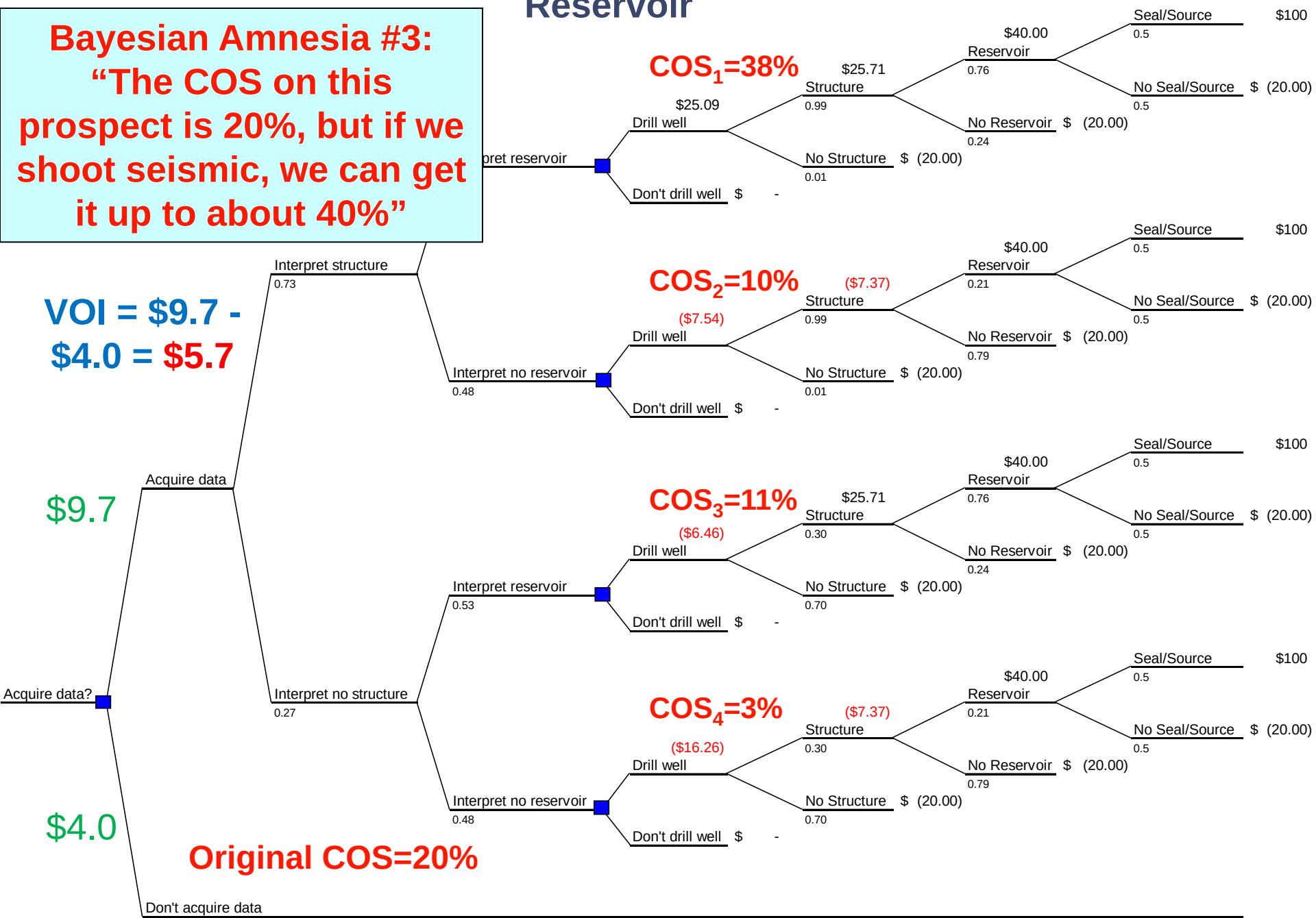
- The reliability of information obtained from high-quality seismic data regarding:
  - Structure: good to very good
  - Reservoir: very poor to fairly good
  - Seal: very poor to poor
  - Source: very poor
- **For the purposes of this exercise, we'll assume that seismic data helps with Structure and Reservoir only**

Incorporating the seismic data into COS



VOI tree incorporating the information gained on Structure & Reservoir

Bayesian Amnesia #3: "The COS on this prospect is 20%, but if we shoot seismic, we can get it up to about 40%"



When one piece of data yields information on more than one independent uncertainty

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Assess the VOI on each uncertainty individually, and then add them

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Build a more complex tree and assess the combined VOI

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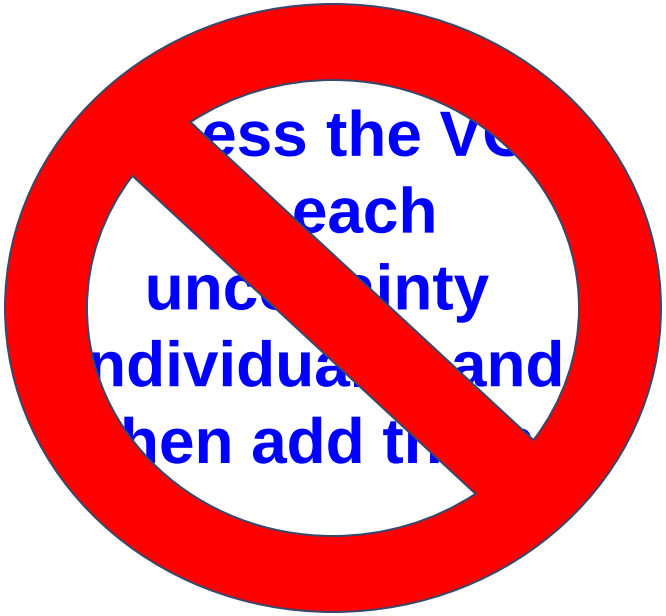

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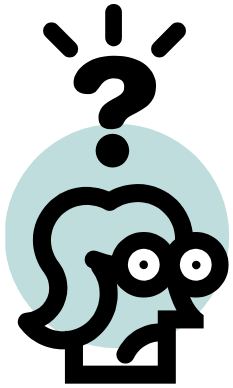
Summary

- Certain types of information cause Bayesian Amnesia
  - Original risk estimates are conveniently forgotten
  - “I’ll take the upside, but I don’t want the downside”
- Applying VOI concepts to situations where data yields information about multiple uncertainties requires some thought
  - More complex trees are required
- VOI estimates are often summed when they shouldn’t be
  - Again: More complex trees are required

Reference

Bratvold, Reidar B., Bickel, J. Eric, and Lohne, Hans Petter, 2007. *Value of Information in the Oil and Gas Industry: Past, Present, and Future,* Society of Petroleum Engineers paper SPE 110378, presented at the SPE Conference in Anaheim, CA, 11-14 November, 2007.



Questions?

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