## Modeling Uncertainty in the Earth Sciences

**Decision making under uncertainty**

**Task 1**

Are the next statements true or false + provide a maximum of 5 lines explanation

1. Any assessment of uncertainty is necessarily subjective
2. Models that include more complex physics are always better than models that are less physically accurate
3. Gathering more information/data about an unknown event will necessarily lead to a reduction of uncertainty, or, at least, uncertainty will remain the same

**Task 2**

Read the paper by Benson and Cole provided on the coursework website under assignment 2.

This task appeals to your analytical skills in understanding the Carbon Capture and Sequestration (CCS) problem and providing ways to introduce decision science in several aspects of CCS. It also aims at making you more familiar with the language of decision analysis

1. What are major sources of uncertainty related to selecting a site for CO2 sequestration?
2. If you were an Energy company, what could be your objectives for CO2 sequestration? What kind of decisions will you be faced with? Are there competing/conflicting objectives?
3. Answer the same question but for the case of the decision maker being the US government and for the decision of introducing Carbon taxes and credits (or not).
4. In these two cases of a decision maker, what type of value functions would you use?
5. What data sources are available in this case for improving the decision?
6. What do you think the role of models of uncertainty for the subsurface formation (such as studied in this course) would be for CCS projects?

**Task 3**

In early 1984, Pennzoil and Getty Oil agreed to the terms of a merger. But before any merger was officially signed, Texaco offered Getty a substantially better price and as a consequence, Getty Oil reneged on the deal and sold to Texaco. Pennzoil sued in court alleging that Texaco had illegally interfered in the Pennzoil-Getty negotiations. Pennzoil won the case in late 1985 and was awarded $10 billion. However, Texaco stated that it would file for bankruptcy if Pennzoil took lien on its assets and promised to fight to case all the way to the Supreme Court. In 1987, Texaco offered Pennzoil a settlement of $2 billion. Pennzoil and Texaco advisors are thinking that a settlement between $3 and $5 billion would be fair.

Part A.

In this exercise we will construct and solve a decision tree that is a simplification of this case from actual life using the following data. The ultimate decision by Pennzoil is evidently to either accept or reject the $2 billion. However, things get more complicated. Instead of rejecting, Pennzoil is considering a $5 billion counter offer and we know that upon such counteroffer three possible scenarios could take place

Texaco accepts the $5 billion, probability = 0.15

Texaco refuses the counter-offer, probability = 0.5

Texaco has its own (lower) counter-offer of $3 billion, probability = 0.35

Pennzoil can accept or refuse the last offer, in the latter case the court will decide. In the event the case does go to court anything could happen for Texaco, namely, from receiving the 10 billion in the first court decision to loosing the case altogether ($0). To make things simpler, we consider the uncertain court decision to be one of four possible scenarios for the settlement amount (in favor of Pennzoil):

P(court decision = $10 billion) = 0.25; P(court decision = $7 billion) = 0.15;

P(court decision = $4 billion) = 0.25 P(court decision = $0 billion) = 0.35;

Your task is to draw the decision tree for this decision problem. Make sure to use circles for uncertain events and squares for decisions, write the probabilities and “payoffs” at the appropriate locations in the tree. Solve the decision problem. What should Pennzoil do? Note that there are two decisions in the tree, what is your conclusion on each one?

Part B

“Expected Value or Payoff” is something we should considered over the long run, i.e. for a large number of trials and is associated with a risk neutral preference. Is such expected value relevant in this particular court case? Determine the risk profile for each alternative:

What is the risk profile for “Accept $2 billion”?

What is the risk profile for “Put a counter-offer of $5 billion”?

What do you conclude from this assessment?

Part C

Perform a one-way sensitivity analysis with regard to all probabilities on this decision tree. What do you conclude from this analysis?