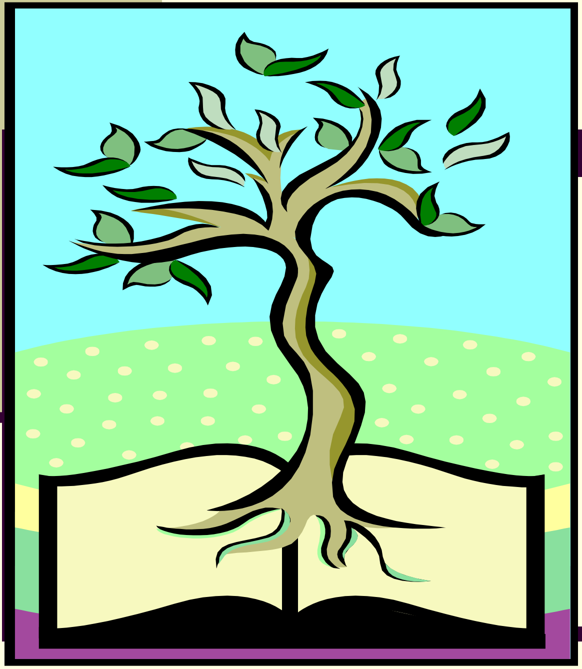
Decision Analysis:
Choice of the Best Alternative



Alamanda
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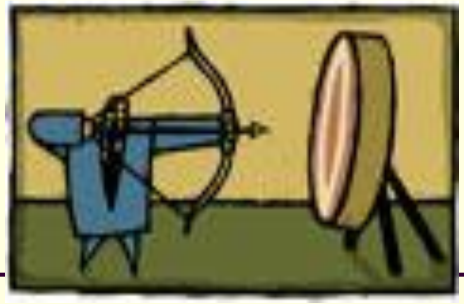
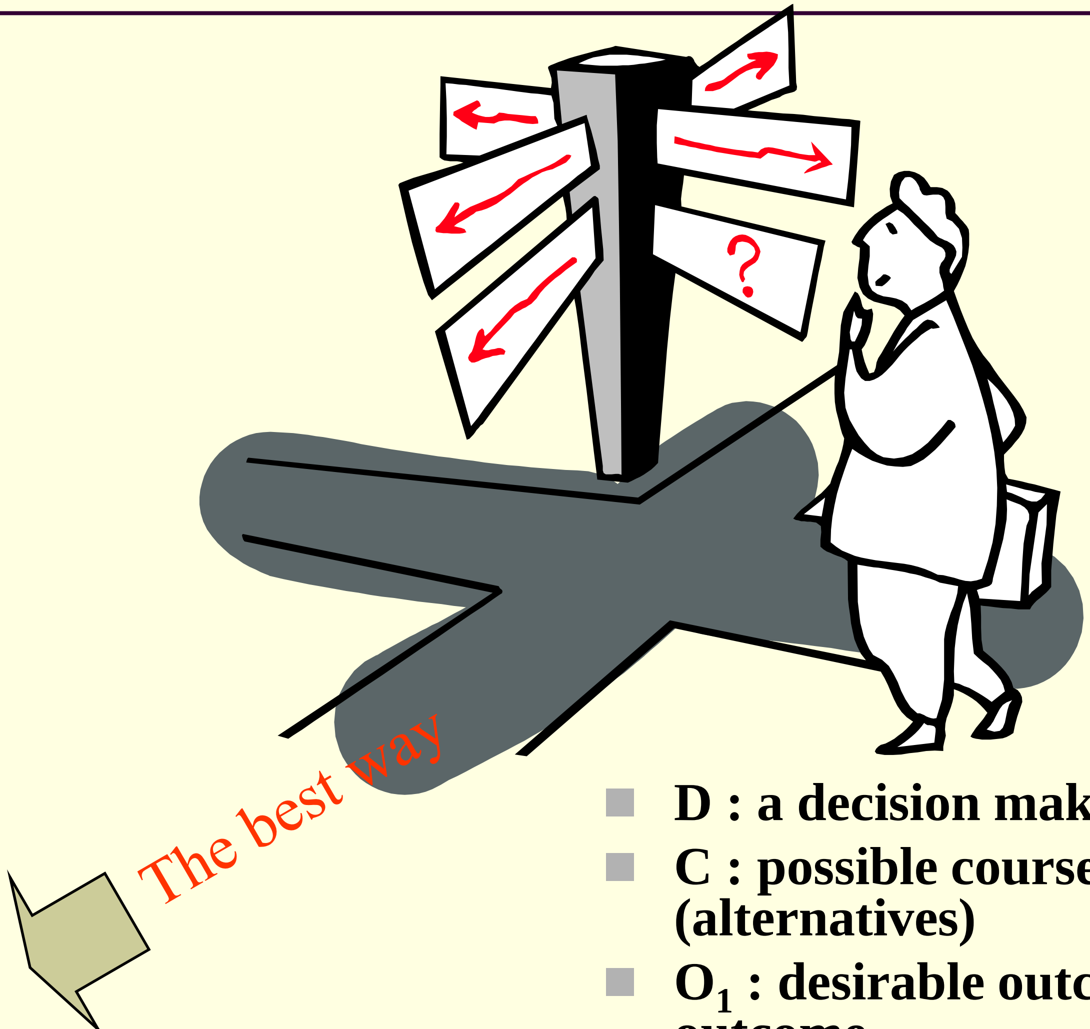
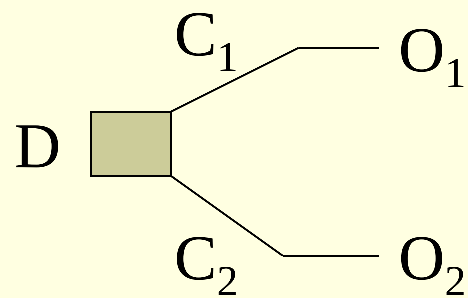


Course Objectives

- **Understanding how to set “*what is problem*”;**
- Ability to choose the best alternative among available alternatives by:
  - **Identifying their consequences;**
  - Asking experts, especially if there are *multi criteria/attributes*.
- Ability to analyze confrontation;
- Enjoy and survive during this course!

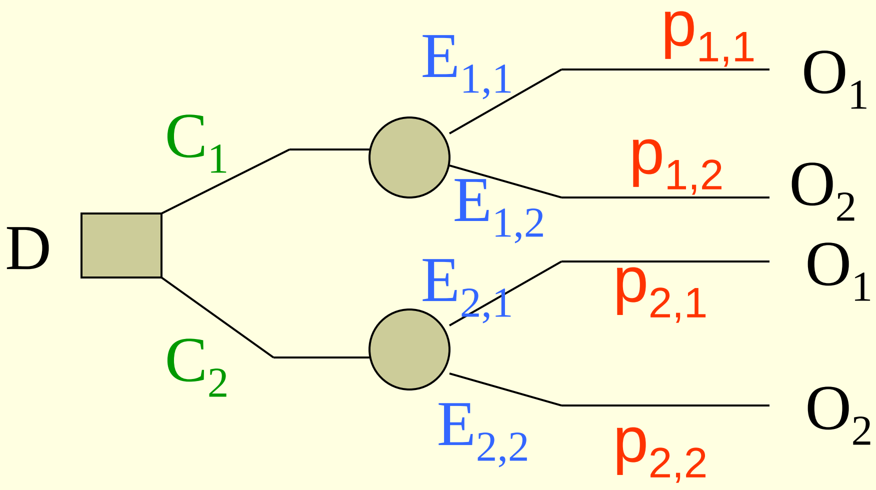
Problems of Choice





- **D : a decision maker**
- **C : possible courses of action (alternatives)**
- **O_1 : desirable outcome; O_2 : undesirable outcome**

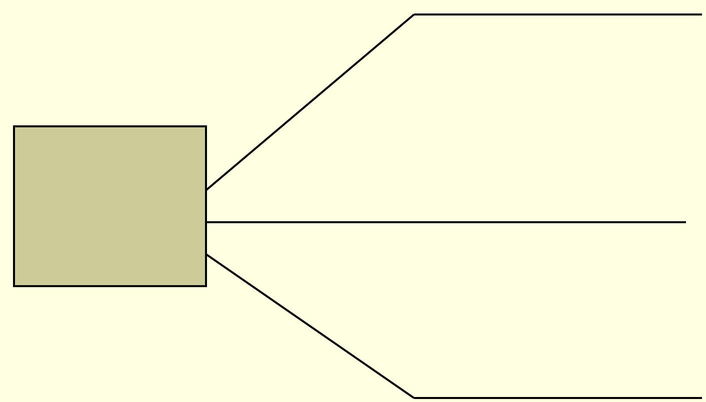
Model of Decision Analysis



- D : a decision maker
- C : possible courses of action (alternatives)
- O_1 and O_2 : possible outcomes/consequences/payoffs
- $E_{i,j}$: Events (State of Natures/SON)
- $p_{i,j}$: probabilities

Structure of Decision Tree

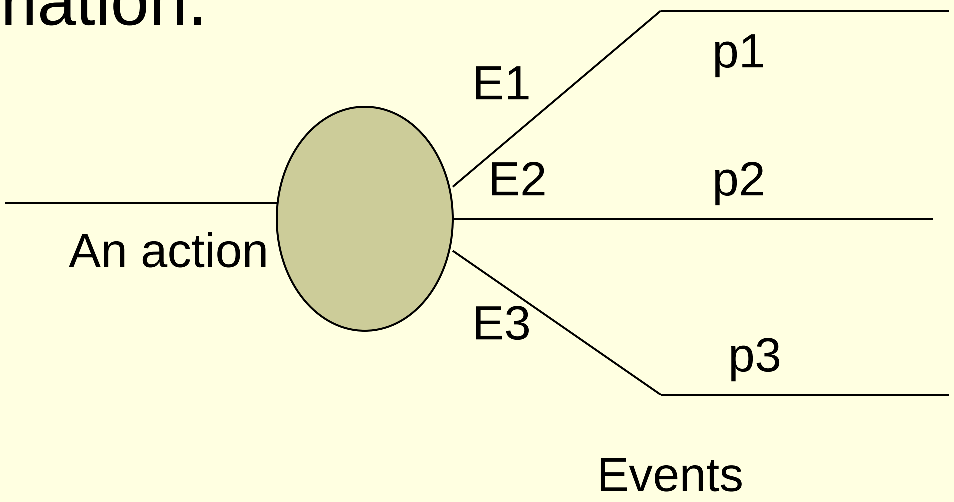
- Decision Node
  - Alternatives available for decision maker to choose;
  - Situation controllable by decision maker.



Alternatives of actions

Structure of Decision Tree

- Event Node
  - Events may happen after every action made by decision maker;
  - Uncontrollable by decision maker;
  - Decision maker only has information about probability of each event → no complete information.



Building Decision Tree

1. Identify what decisions should be made by DM;
   - What are the *first* decision, and *next* decisions to be made?
2. Identify what SON happen after each decision;
3. Draw decision node and event node (SON);
4. Complete information about probabilities;
5. Complete information about payoff.

Goferbroke Company Case

Goferbroke Company(1)

- **Max Flyer** is the founder of and sole owner of the Goferbroke Company, which develops oil wells in *unproven territory*. Max's friends refer to him affectionately as *a wildcatter*. However he prefers to think himself as *an entrepreneur*. He has poured his life saving's into the company *in the hope of making it big with a large strike of oil.*
- Now his chance possibly has come. His company *has purchased various tracts of land* that larger oil companies have spurned as unpromising even though they are near some large oil fields. *Now Max has received an exciting report about one of these tracts. A consulting geologist has just informed Max that he believes there is one chance in four of oil there.*
- Max has learned from bitter experience to be skeptical about the chances of oil reported by consulting geologist. Drilling for oil on this tract would require an investment of about **$100,000.** If the lands *turns out to be dry (no oil)*, **the entire investment would be lost.** Since his company doesn't have much capital left, this lost would be quite serious.

Goferbroke Company(2)

- On the other hand, *if the tract does contain oil*, the consulting geologist estimates that there would be enough there to generate a net revenue of approximately **$800,000,** leaving an approximate profit of:
  - Profit if find oil = Revenue if find oil – Drilling cost

    = $800,000 - $100,000

    = **$700,000**

- There is another option that *another oil company* has gotten wind of consulting geologist's report and so has offered to purchase the tract of land from Max for **$90,000**. *This is very tempting.* This too would provide a welcome infusion of capital into the company, but without incurring the large risk of a very substansial loss of $100,000.

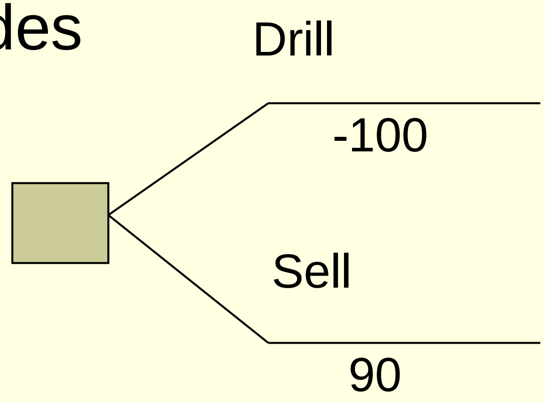
Decision Trees of Goferbroke

- **Decision tree** is decision making help tools that could describe entire alternatives with whole events that may happen (SoN).
- Showing : Alternatives, SoN, Prior Probability, and Payoff.
- Using Bayes' Decision Rule to choose the best action.

DT of Goferbroke's Case

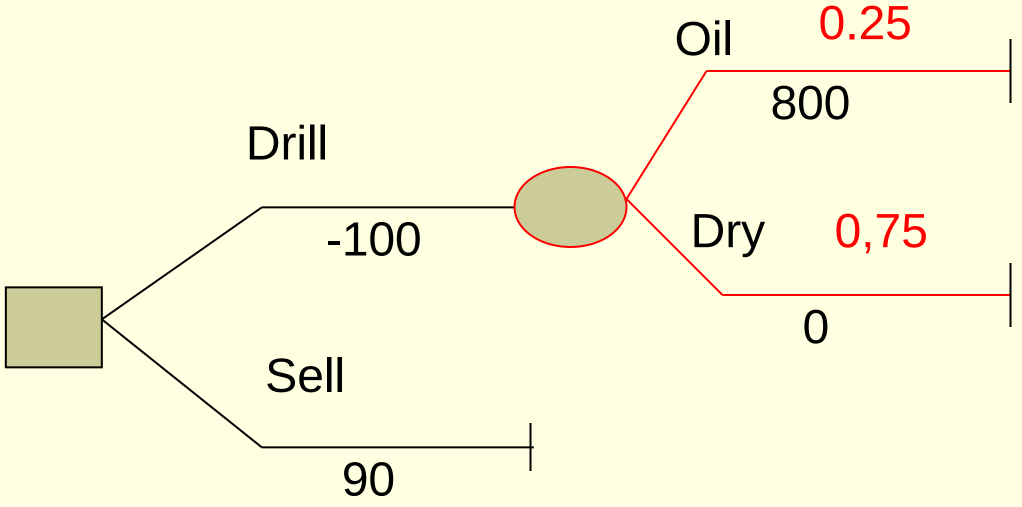
- Decision:
  - Drill or Sell the Land
- SON
  - Oil or Dry

Decision nodes



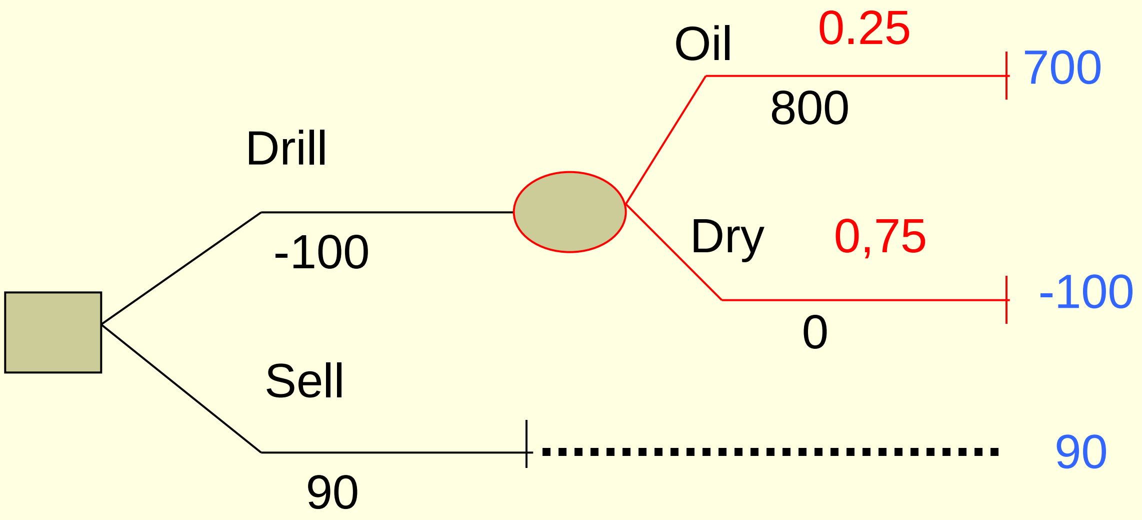
DT of Goferbroke's Case

- Event nodes



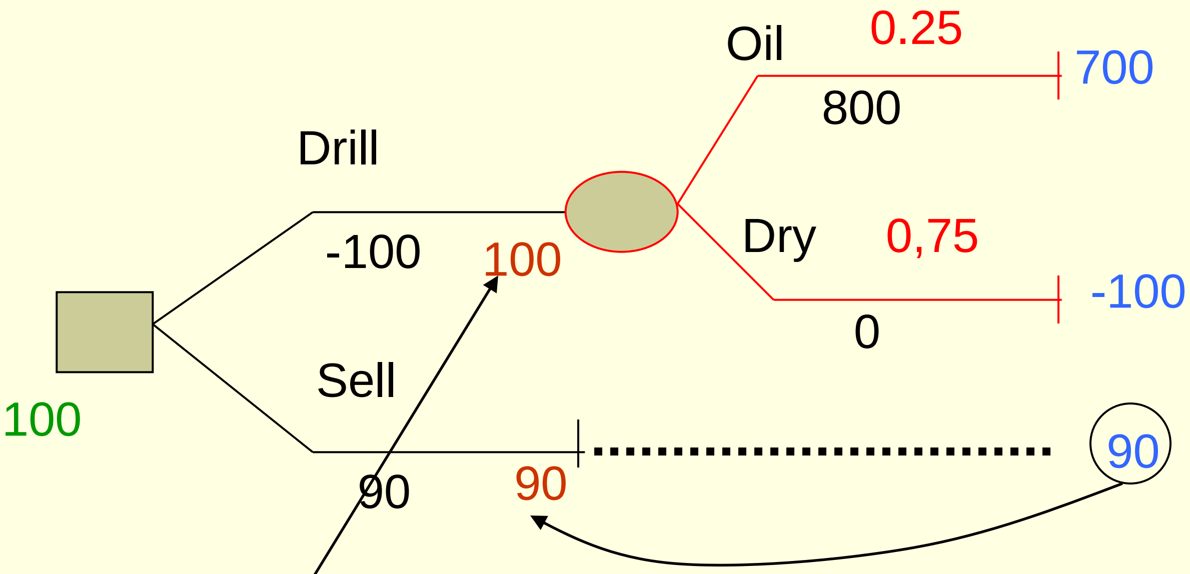
DT of Goferbroke's Case

- Payoff



DT of Goferbroke's Case

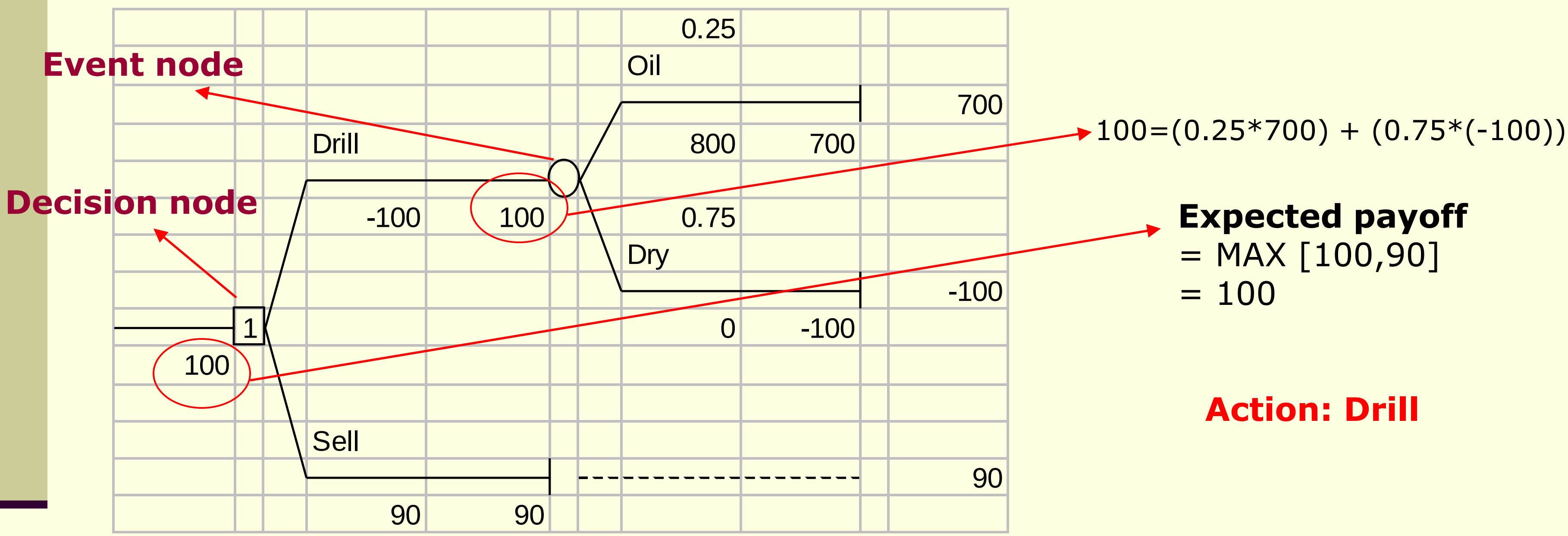
- Payoff



- Expected Value (EV) per event node;

100=(0.25*700) + (0.75*(-100))

Using Treeplan software



Goferbroke's Case Continued

- Survey by geologist will provide more accurate information about *P(oil);*
- How if Max has to decide two alternatives:
  1. **Do survey before drill/sell**
  2. **Drill/sell without Survey**
- Events:
  - Do Survey
    - **FSS** : Favorable Seismic Sounding : Oil is fairly likely
    - **USS** : Unfavorable seismic sounding: Oil is quite unlikely.
  - Drill or Sell
    - **Oil**
    - **Dry**

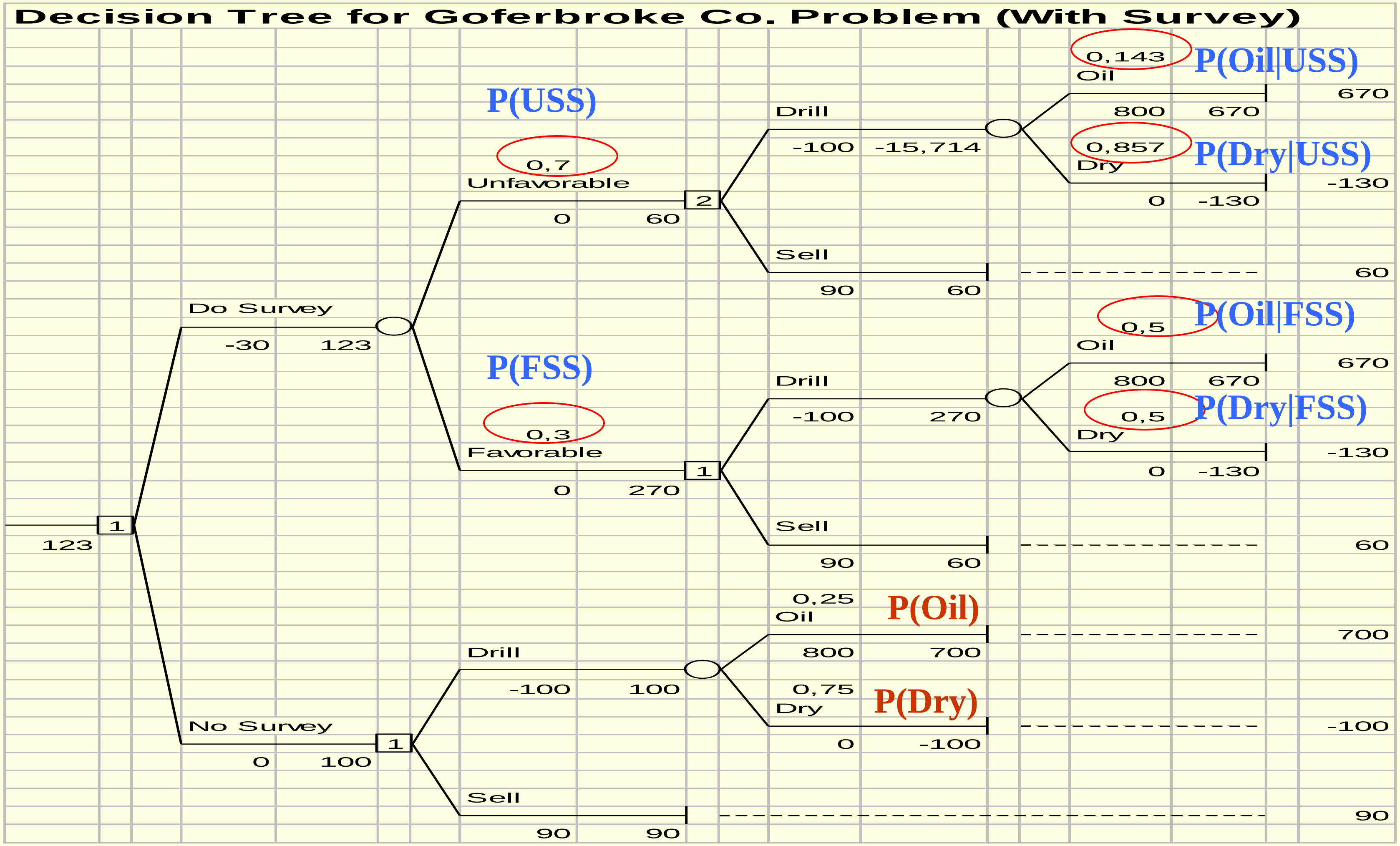
Max`s Experience

- **P(state)→ prior; which is P(Oil)=0.25 & P(Dry)=0.75;**
- **P (finding|state)→ being known based on Max's experiences; which is**
  - **P(FSS|Oil)=0.6,**
  - **P(USS|Oil)=0.4,**
  - **P(FSS|Dry)=0.2, and**
  - **P(USS|Dry)=0.8**

Which:

- State : Oil and Dry;
- Finding : FSS and USS;
- FSS : favorable seismic sounding; oil is fairly likely;
- USS : unfavorable seismic sounding; oil is quite unlikely.

Leveled Decision Analysis

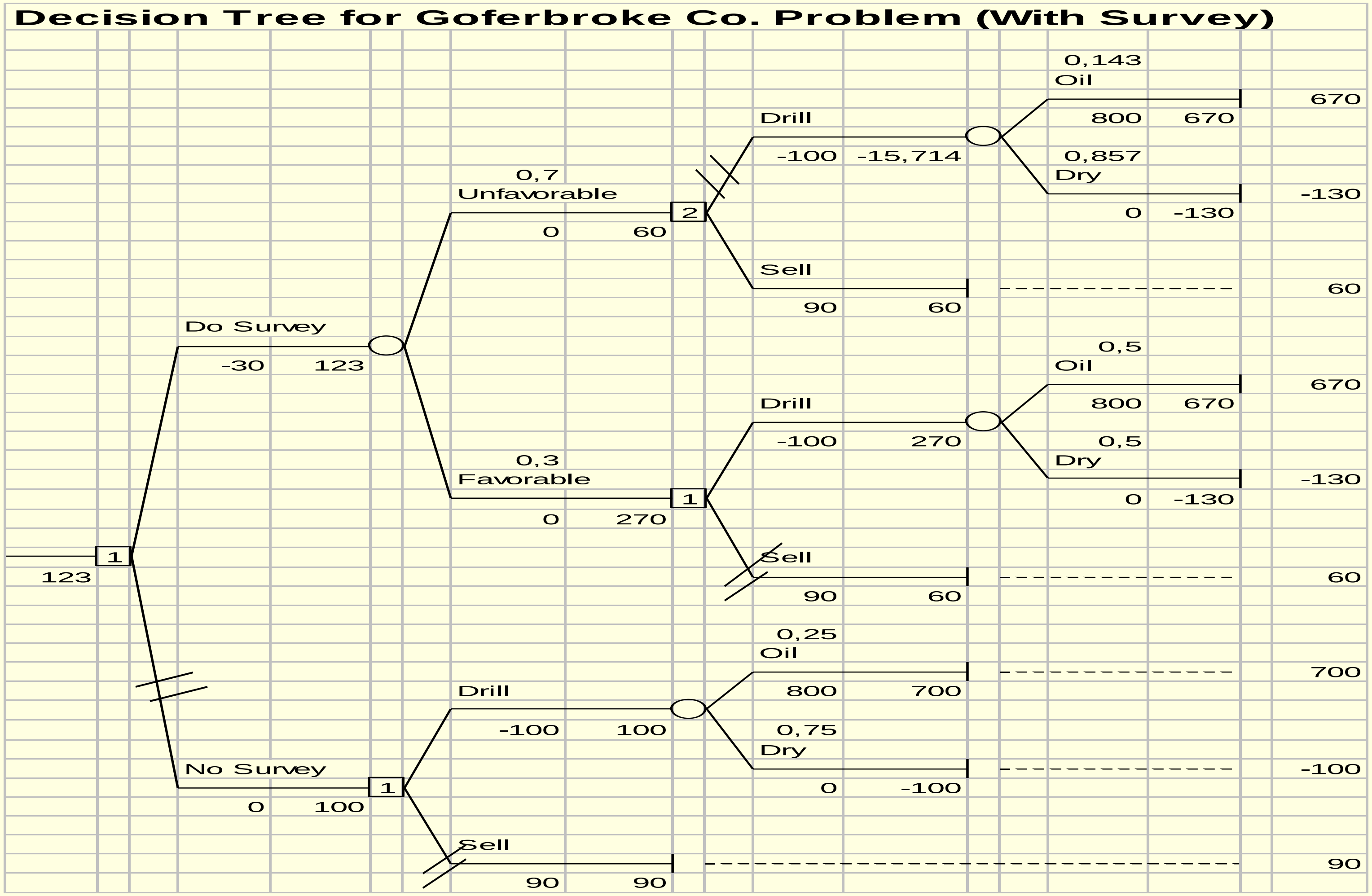


Decision Tree: What-If Analysis

Sensitivity Analysis

The Study of how different assumptions about future (parameters) would affect the recommended decision.

Current Solution



Do survey, if USS then Sell, else Drill

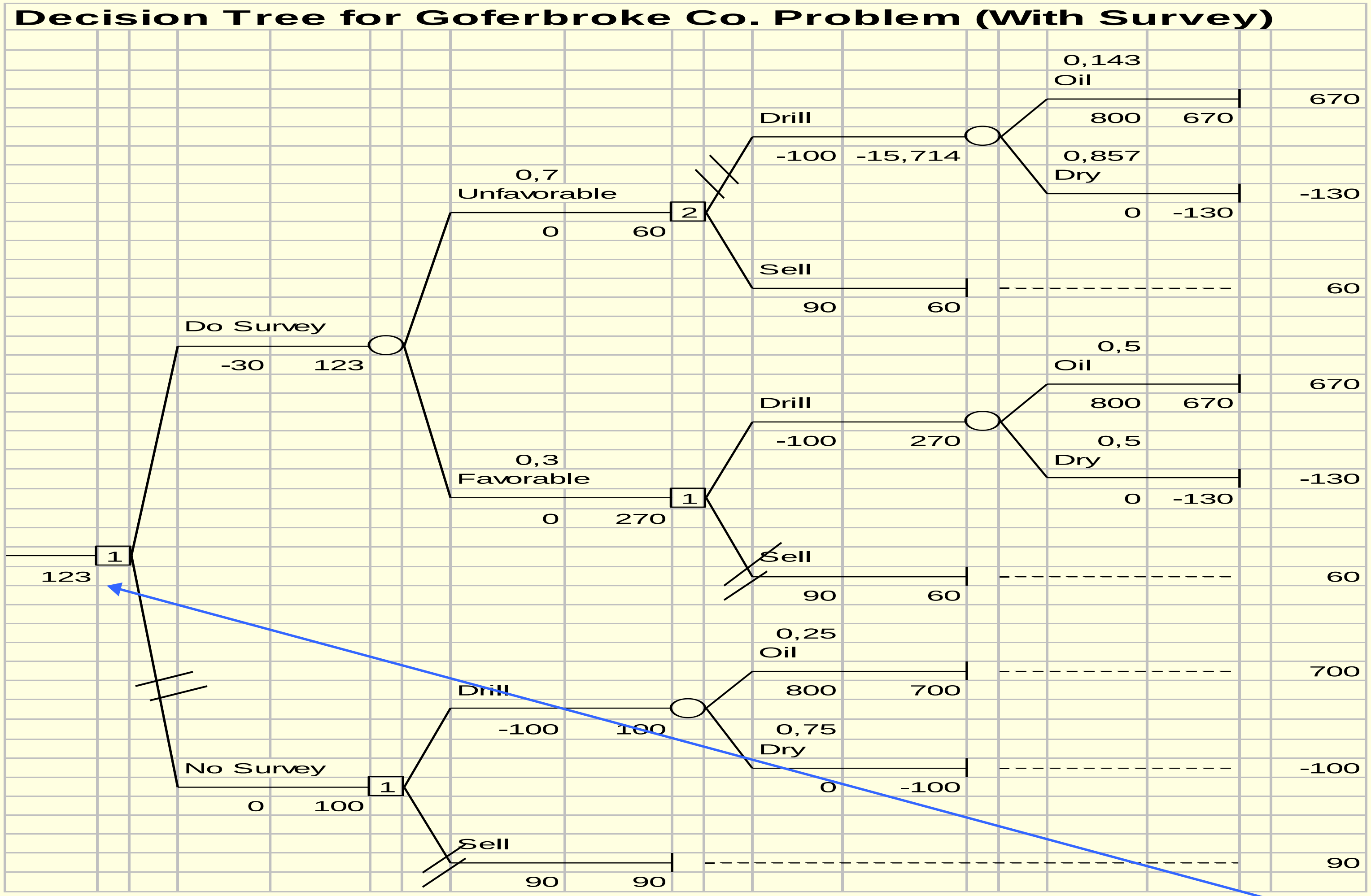
Sensitivity Analysis Graph

- There are three Sensitivity Analysis tools that being depicted in graph to help analyze Decision Tree solution:
  - Plot graph
  - Spider graph
  - Tornado graph
- All of these graphs are built by Sensit-Sensitivity Analysis software.

Sensitivity Analysis Graph Tips

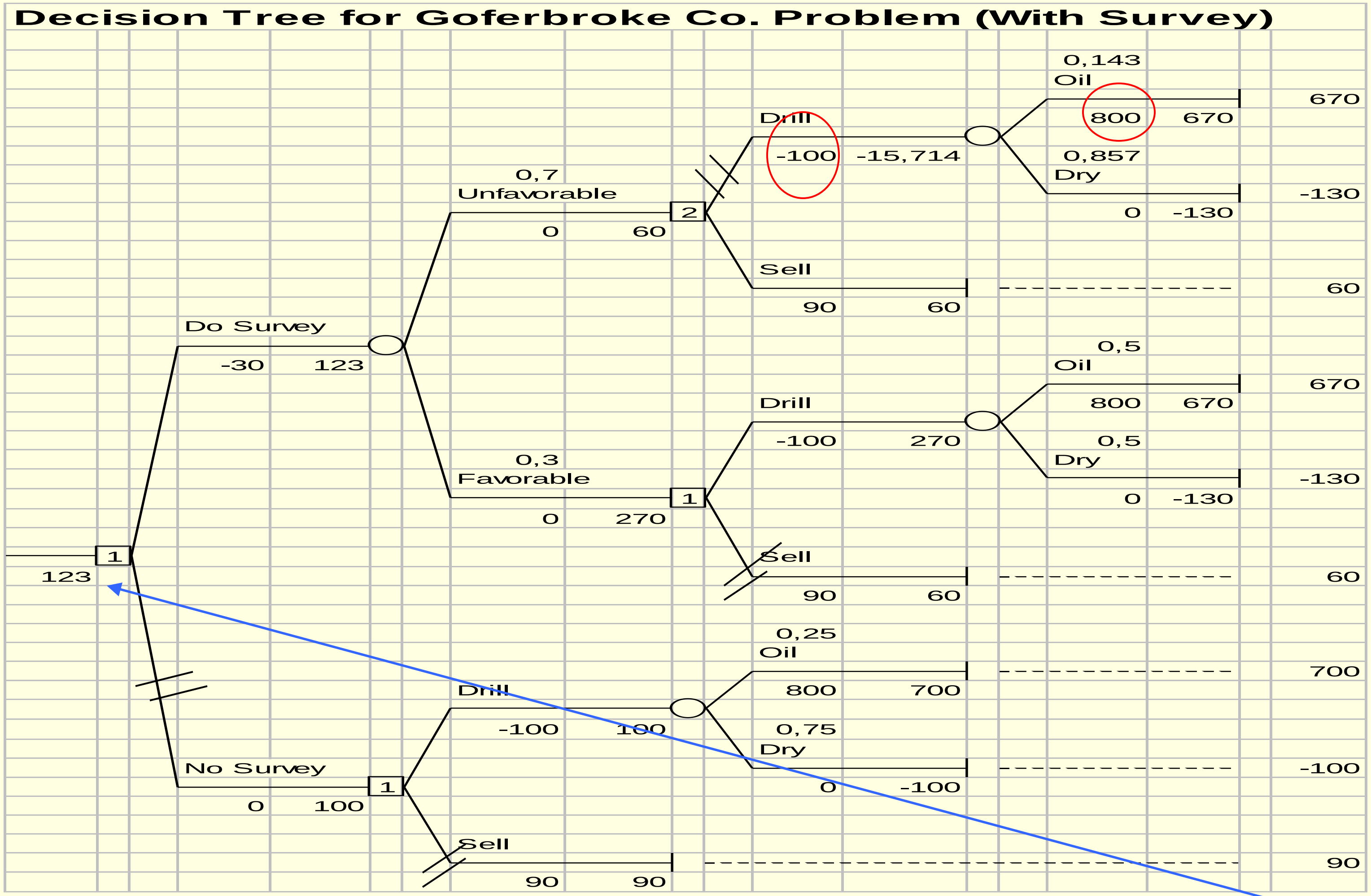
- Plot graph were sensitivity analysis tools that being used to investigating the effect of prior probability of finding oil on the expected payoff;
- Spider graph were sensitivity analysis tool that being used to investigating how the expected payoff would change if one of parameters changes (the cost or revenues) by up to plus or minus 10%;
- Tornado diagram are being used to analyze different parameters that had different degrees of variability on the expected payoff.

Sensitivity Analysis(1)



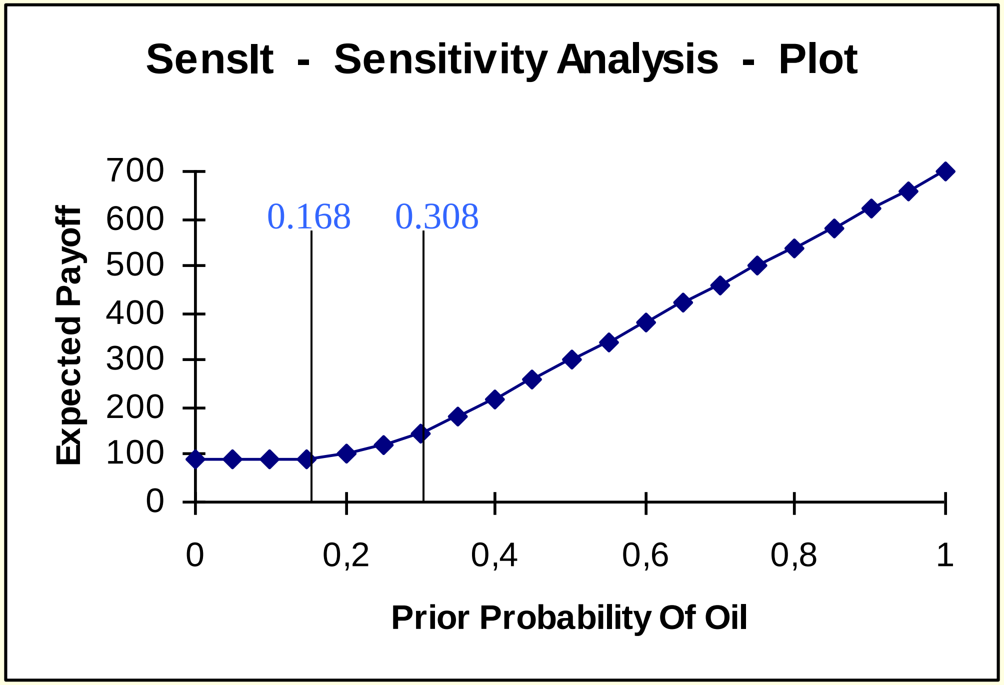
Effect of P(oil) and P(dry) on expected payoff

Sensitivity Analysis(2)



Effect of revenue and costs on expected payoff

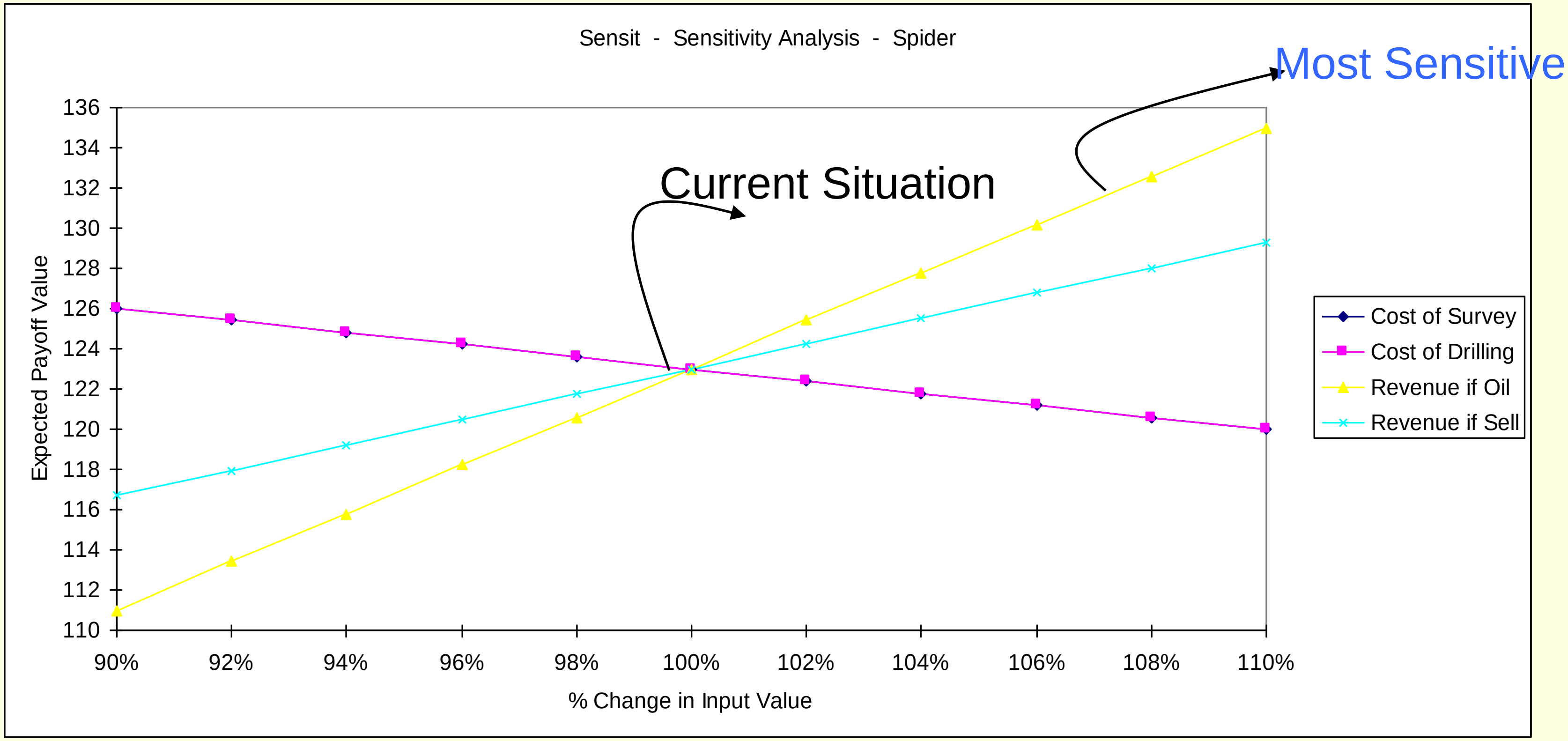
Sensit-Sensitivity Analysis-Plot



Let p = prior probability of oil;

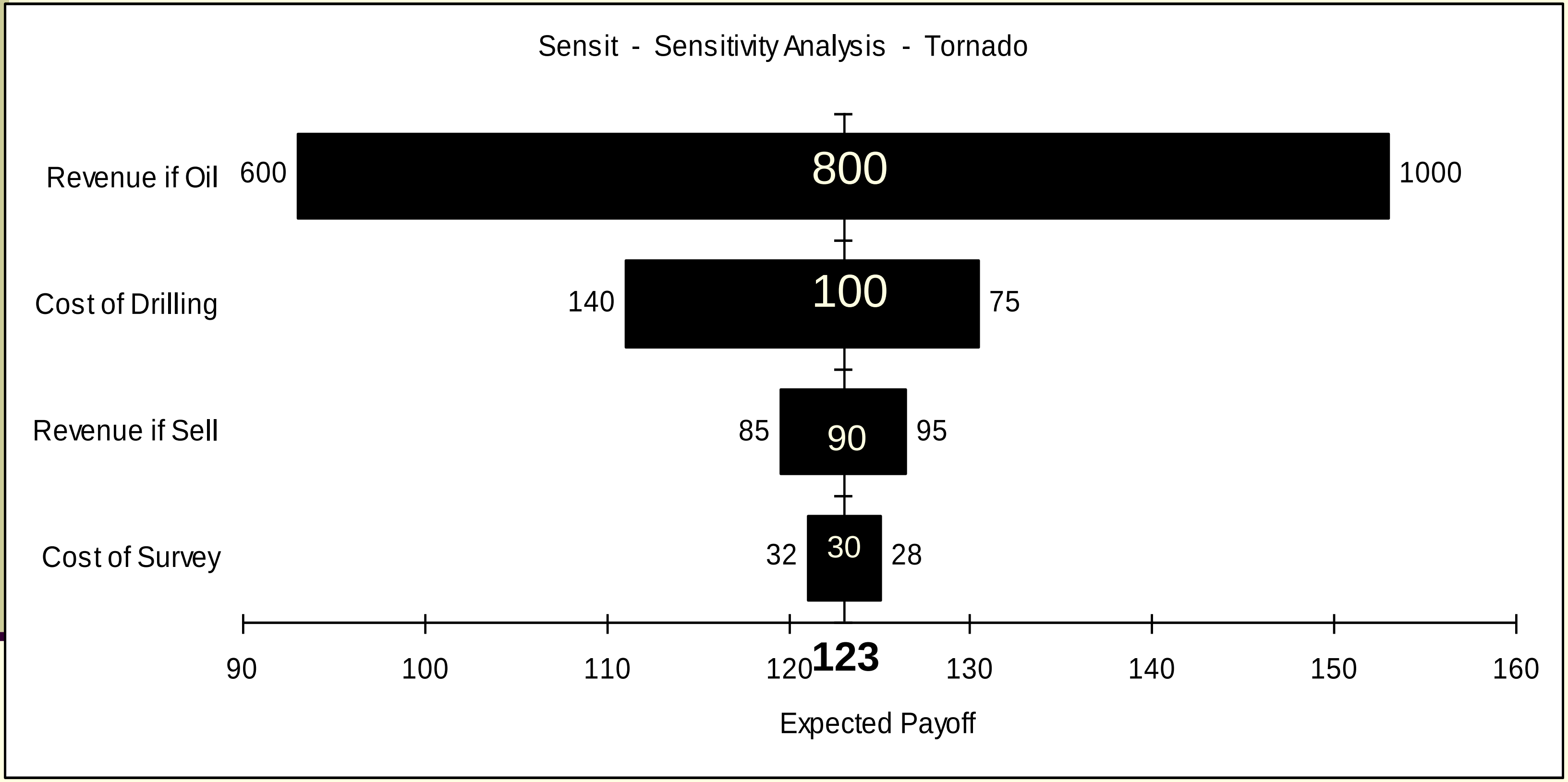
- If $p \leq 0.168$, then sell the land (no seismic survey);
- If $0.169 \leq p \leq 0.308$, then do the survey,
  - drill if favorable and sell if not;
- If $p \geq 0.309$, then drill for oil (no seismic survey)

Sensit-Sensitivity Analysis-Spider



Conclusion : Payoff more influenced by Revenue if Oil variable than others.

Sensit-Sensitivity Analysis-Tornado

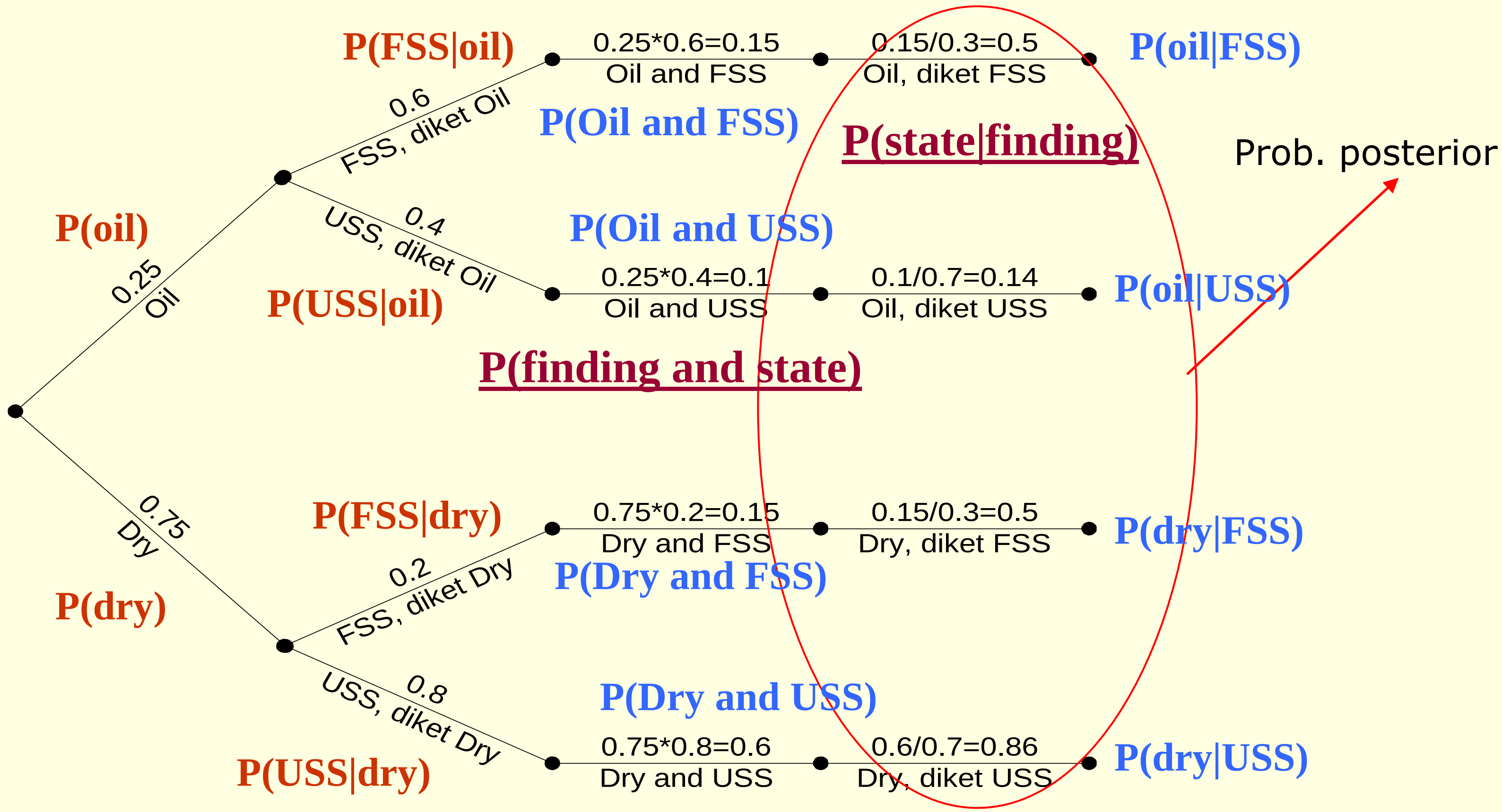


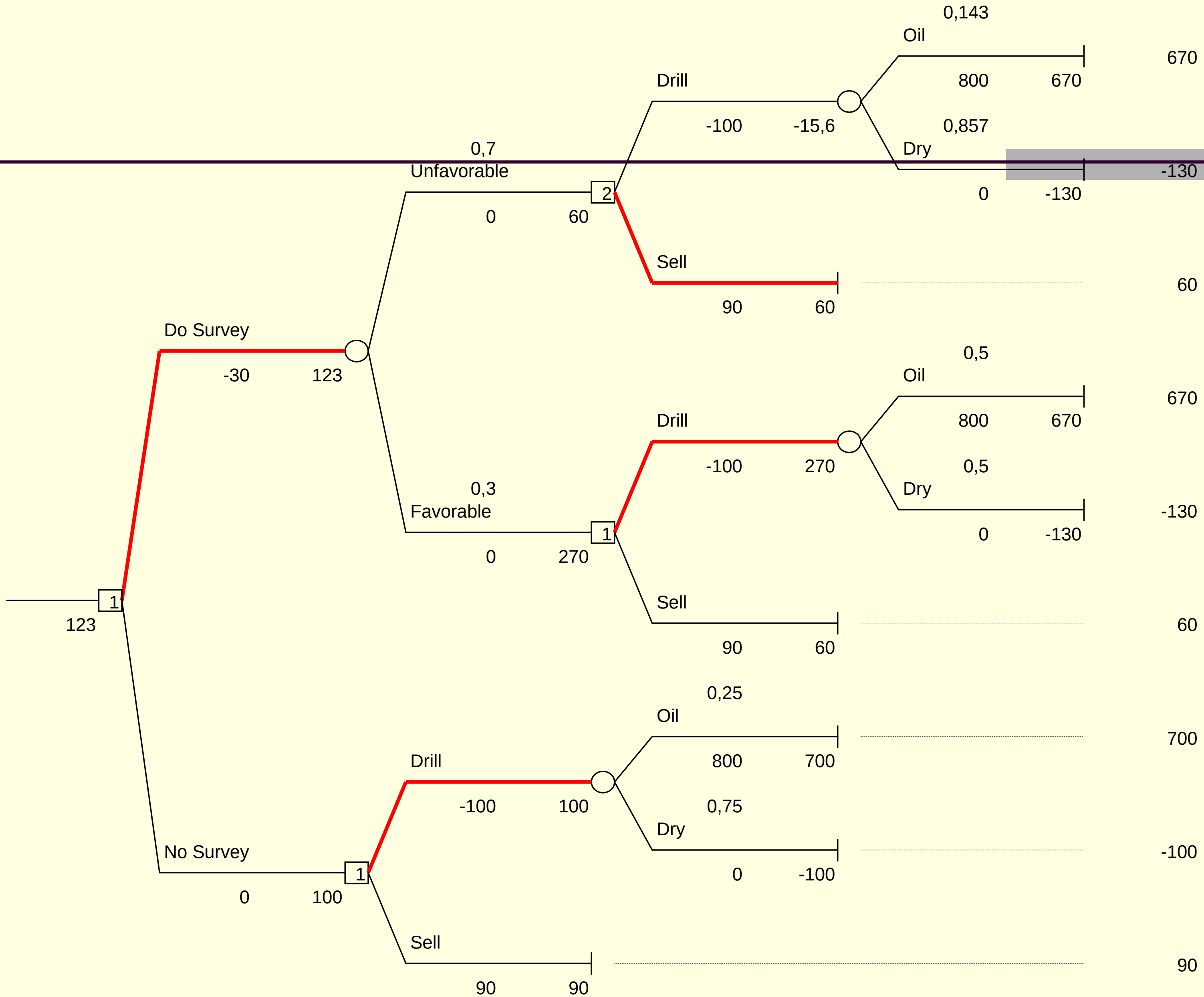
Conclusion : Although r**evenue if oil 25% reduced, but expected payoff still > $ 90,000 (Drill is robust)**

Thanks

Posterior Probability

- **Given:**
  - **P(state)=prior probability: P(oil) and P(dry)**
  - **P(finding|state)** = Max's experience on probabilities of finding (FSS or USS) could occur if some SoN (oil or dry) has been already happened.





0,143
Oil
670
Drill
800
670
-100
-15,6
0,857
0,7
Dry
Unfavorable
-130
2
0
-130
0
60
Sell
60
90
60
Do Survey
0,5
-30
123
Oil
670
Drill
800
670
-100
270
0,5
0,3
Dry
Favorable
-130
1
0
-130
0
270
Sell
1
60
123
90
60
0,25
Oil
700
Drill
800
700
-100
100
0,75
Dry
No Survey
-100
1
0
-100
0
100
Sell
90
90
90

Posterior Probability Formula

Given :

- P(state)→ prior probability: P(Oil)=0.25 & P(Dry)=0.75;
- P(finding|state)→ P(FSS|Oil)=0.6, P(USS|Oil)=0.4, P(FSS|Dry)=0.2, and P(USS|Dry)=0.8.

Then :

- P(State and Finding)=P(State)P(Finding|State)
- such that : P(Oil and FSS)=P(Oil)P(FSS|Oil)

→ $$P(state \mid finding) = \frac{P(state \text{ and } finding)}{P(finding)}$$

And P(finding):

- P(FSS)=P(oil and FSS)+P(dry and FSS)
- P(USS)=P(oil and USS)+P(dry and USS)

GRADE	***MALE***	***FEMALE***	***TOTAL***
A	30	40	70
B	10	20	30
TOTAL	40	60	100

$$P(B)=\frac{30}{100}$$

$$P(A)=\frac{70}{100}$$

GRADE	***MALE***	***FEMALE***	***TOTAL***
A	30	40	70
B	10	20	30
TOTAL	40	60	100

$$P(Male) = \frac{40}{100}$$

$$P(Female) = \frac{60}{100}$$

GRADE	***MALE***	***FEMALE***	***TOTAL***
A	30	40	70
B	10	20	30
TOTAL	40	60	100

$$P(A \quad and \quad Male) = P(Male \quad and \quad A) = \frac{30}{100}$$

$$P(B \quad and \quad Male) = P(Male \quad and \quad B) = \frac{10}{100}$$

GRADE	*MALE*	*FEMALE*	*TOTAL*
A	30	40	70
B	10	20	30
TOTAL	40	60	100

$$P(B|Male) = \frac{P(B \quad and \quad Male)}{P(Male)} = \frac{10/100}{40/100} = \frac{1}{4}$$

GRADE	***MALE***	***FEMALE***	***TOTAL***
A	30	40	70
B	10	20	30
TOTAL	40	60	100

$$P(Male|B) = \frac{P(Male \quad and \quad B)}{P(B)} = \frac{10/100}{30/100} = \frac{1}{3}$$

GRADE	MALE	FEMALE	TOTAL
A	30	40	70
B	10	20	30
TOTAL	40	60	100

$$P(B) = P(B \quad and \quad Male) + P(B \quad and \quad Female)$$

$$= \frac{10}{100} + \frac{20}{100} = \frac{30}{100}$$

GRADE	***MALE***	***FEMALE***	***TOTAL***
A	30	40	70
B	10	20	30
TOTAL	40	60	100

$$P(Male) = P(A \quad and \quad Male) + P(B \quad and \quad Male)$$

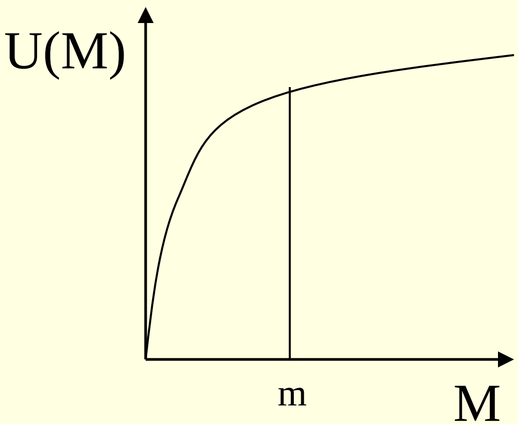
$$= \frac{30}{100} + \frac{10}{100} = \frac{40}{100}$$

Max`s Preference on Risk

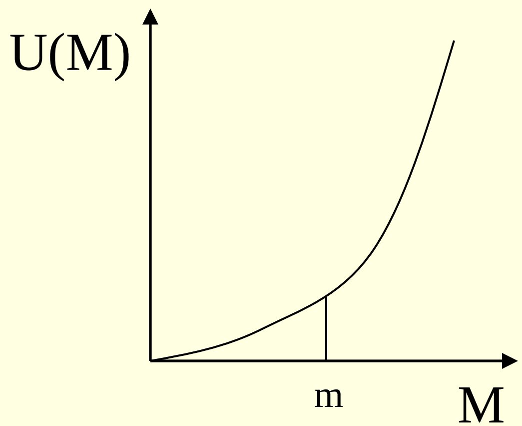
- According to Max, loss as much as 130 thousands dollar in current difficult time gives deadly effect to his company;
- But, in normal condition, loss as much as 130 thousands dollar can be handled easily.

1. **Pay off in unit money can not accommodate DM's preference on risk**
2. **It is needed to consider DM`s preference on risk into payoff**
3. **Utility function accommodates DM's on risk by transforming payoff in unit money onto utility value**

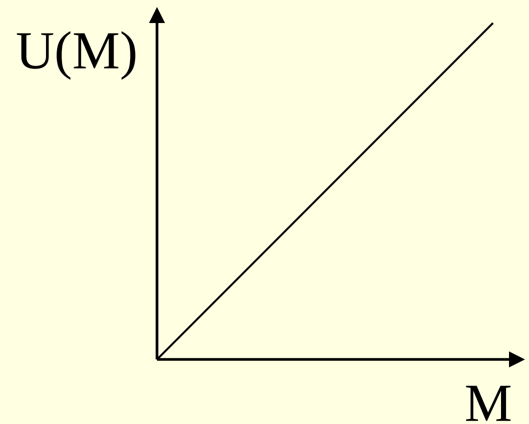
Utility Function for Money



(a) Risk averse



(b) Risk seeking



(c) Risk neutral

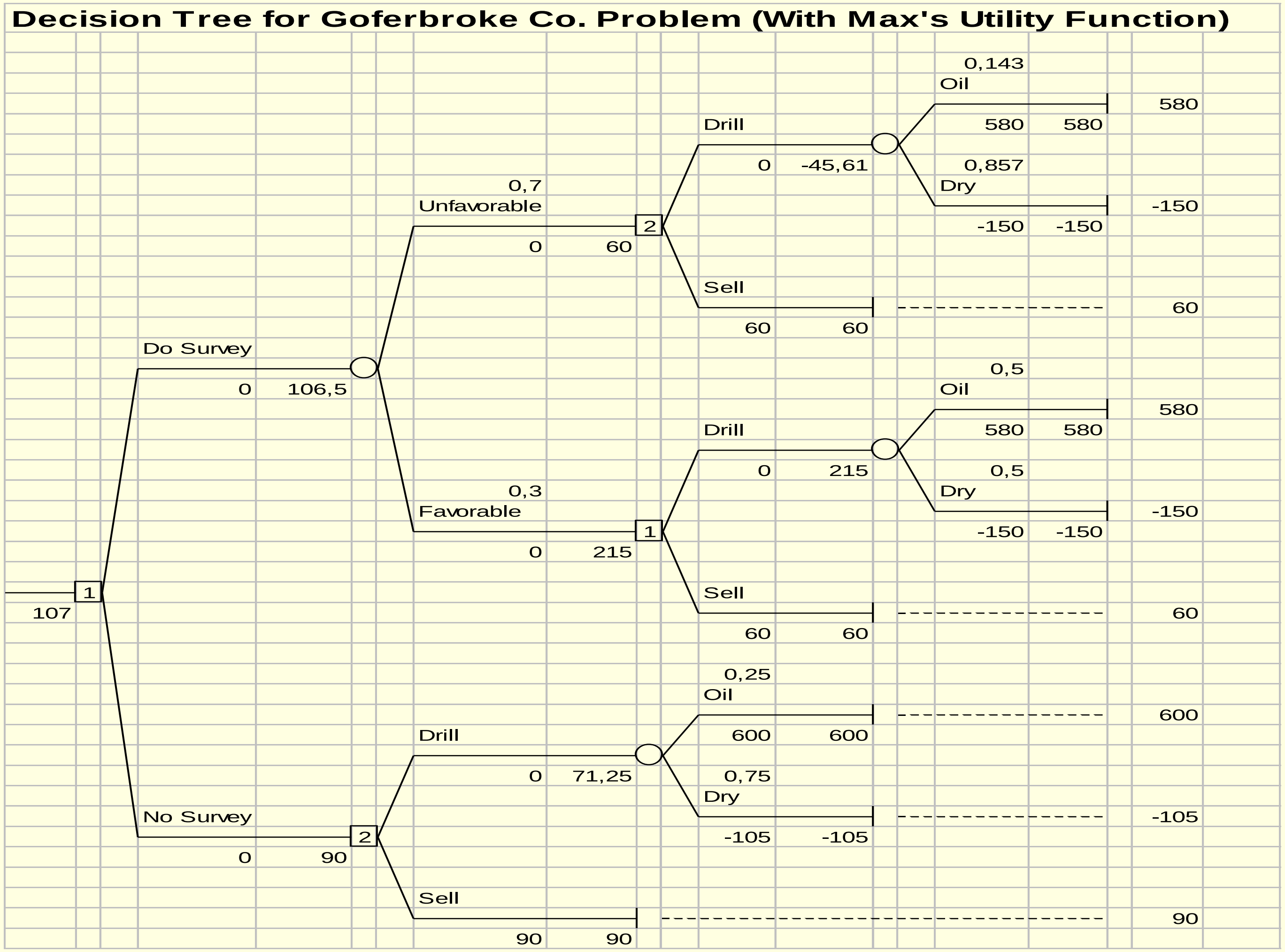
Dealing with the Goferbroke Co. Problem

- Let according to Max U(0)=0, and U(-130)=-150, then calculate U(700);
- Give two choices to Max:
  - A1: Obtain a payoff of 700 with probability *p*.
    Obtain a payoff of –130 with probability (1-*p*);
  - A2 : Definitely obtain payoff of 0.
- Ask Max to choose value of *p* such that he will be indifferent over A1 and A2;
- If Max has chosen *p*=0.2 then
  - E(A1)=E(A2);
  - 0.2U(700)+(1-0.2)U(-130)=0
  - U(700)=600
- Transform other payoffs: U(-100)=-105, and U(90)=90, etc.

Max's Utility Function for Money

Money M	Max's Utility U(M)
-130	-150
-100	-105
0	0
60	60
90	90
670	580
700	600

Revision of DT using Max's Utility Function for Money



Calculation of Utility Function for money

- **Fundamental property** : if a decision maker is indifferent over two alternatives then the alternatives have the same expected utility.