

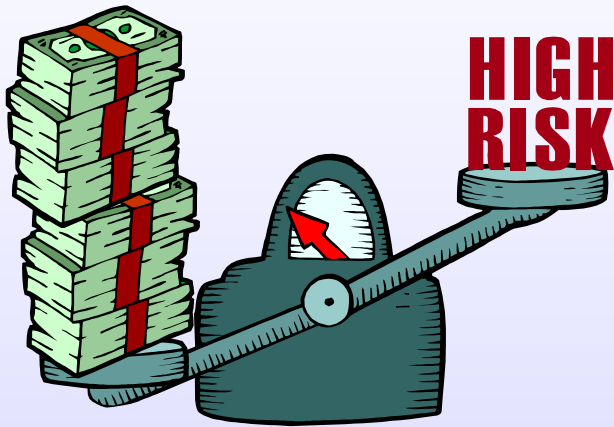
Risk Analysis and Exploration Economics

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The Concept of Risk

- Risk = Uncertainty + Undesirable Consequences
- Risk = Downside potential at a certain Probability Level

Rent vs. Risk



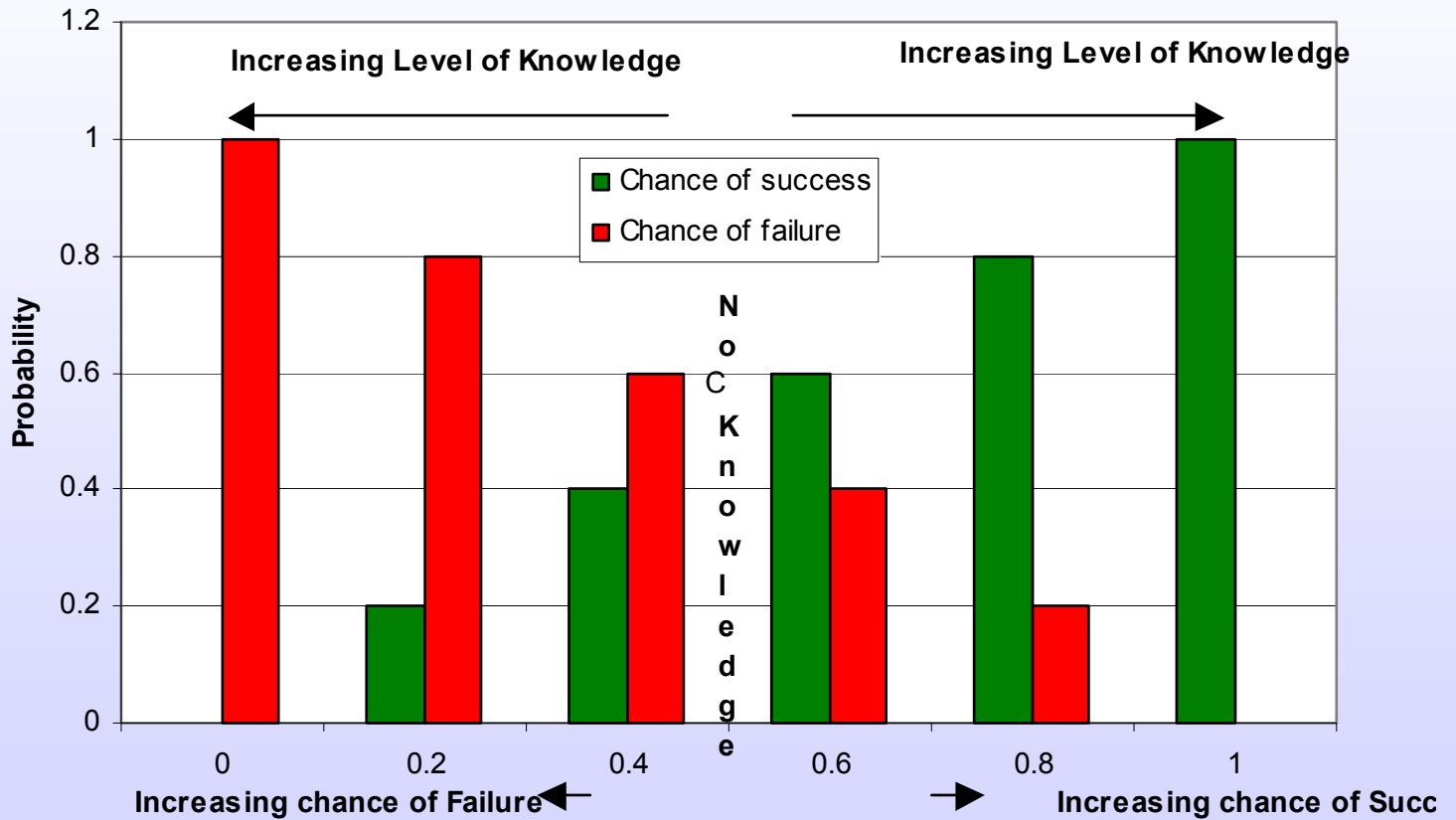
- Most of the exploration possibilities are unsuccessful
- The Profit Margin for the Oil Companies must be large enough to accommodate failures

Risk- & Non Risk-Takers

- Fiscal Terms must account for the large Risk in the Oil Business
 - **Oil Companies are High Risk Takers** Companies reduce risk by diversification
 - **Governments are Low Risk Takers** Governments can reduce risk by introducing a Regressive tax system (Bonuses and Royalties)

Risk vs. Probability

Risk Tranches



Geological & Technical Risks



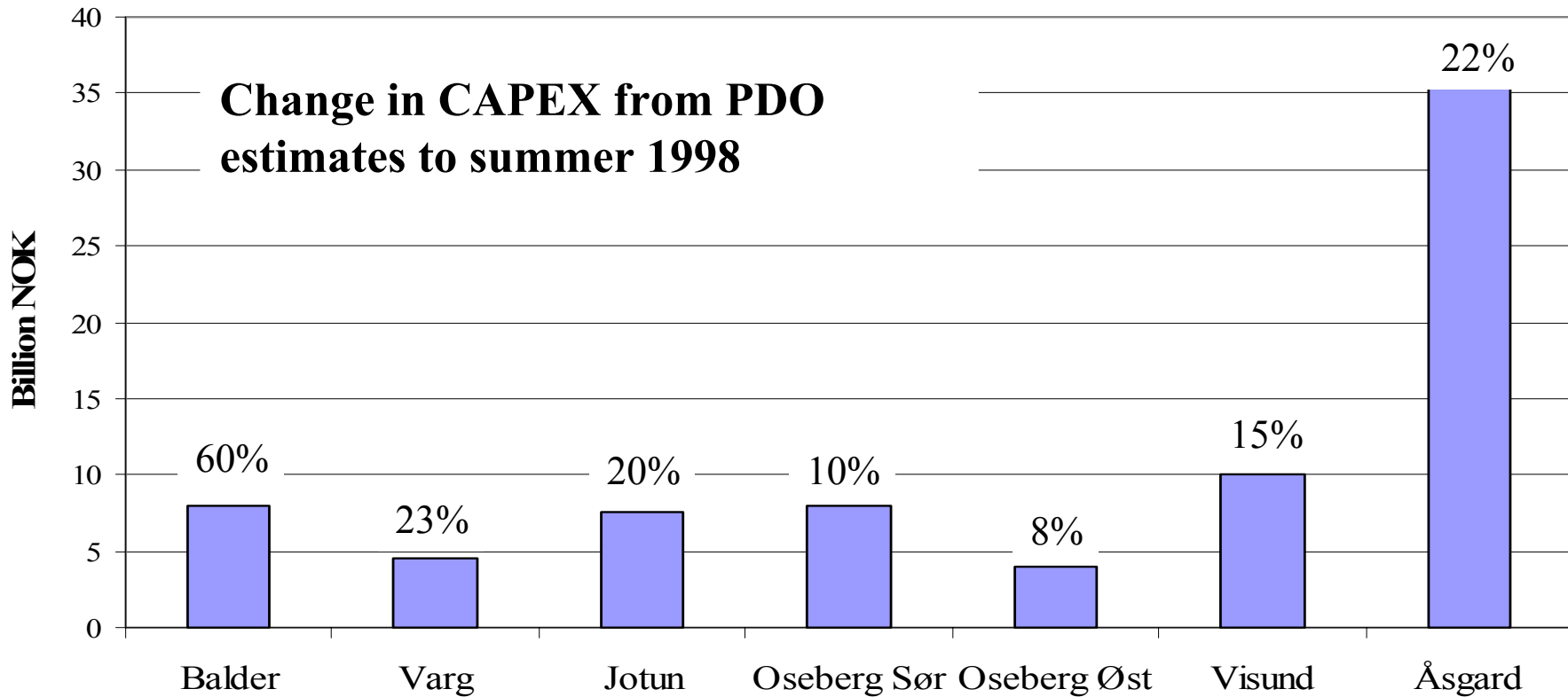
- Exploration
 - Existence of Hydrocarbons
 - Magnitude of Discovery
 - Type of Hydrocarbon
- Development
 - Technical Risk
 - Reservoir Development

Other Risks

- Fiscal
 - Changes in fiscal terms
- Economic
 - Exploration and development costs
 - Hydrocarbon prices
- Political

Profitability and the risk Technological uncertainty

...costs overruns in Norwegian Projects 1998

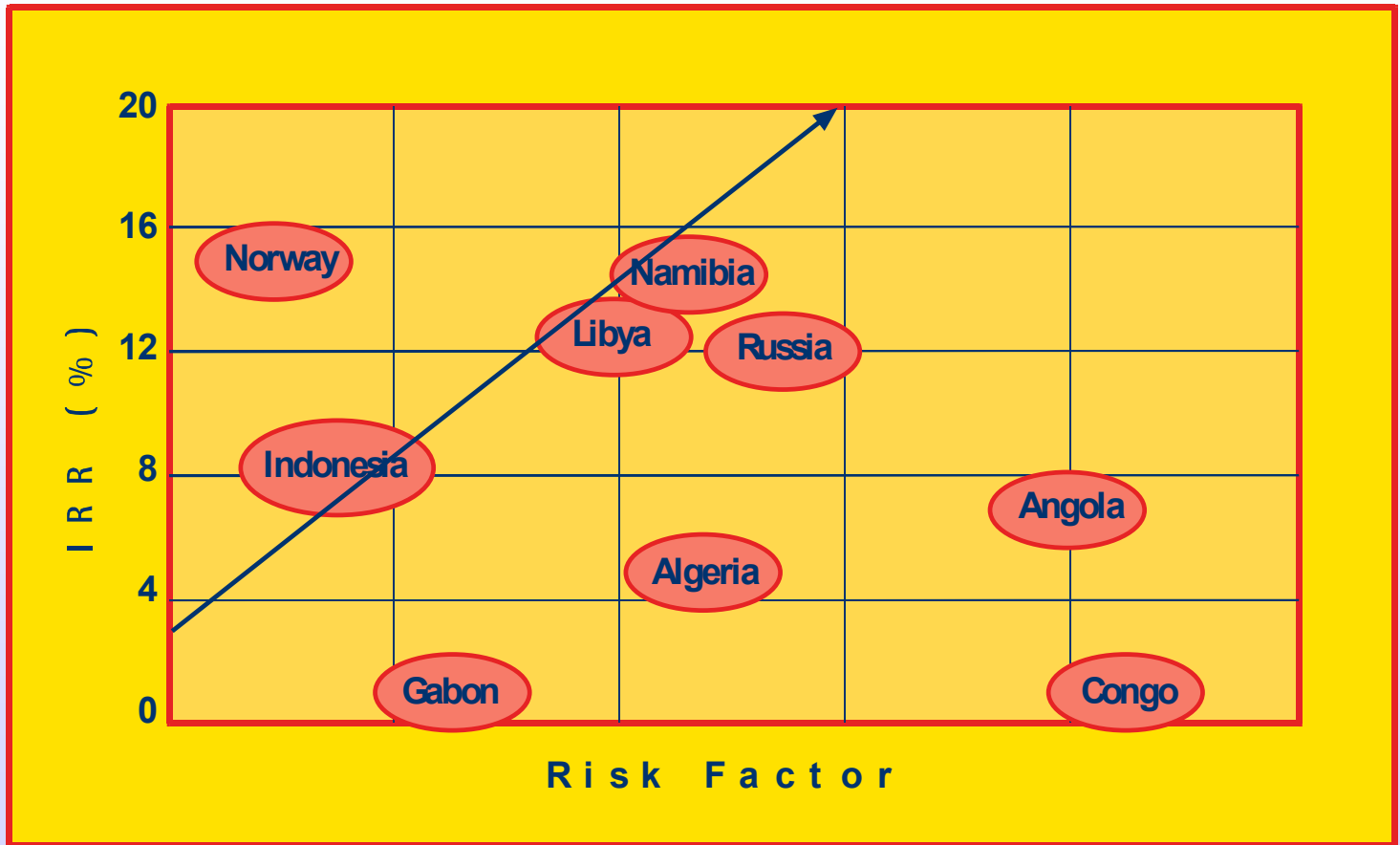


Source: MIE

Political Risk

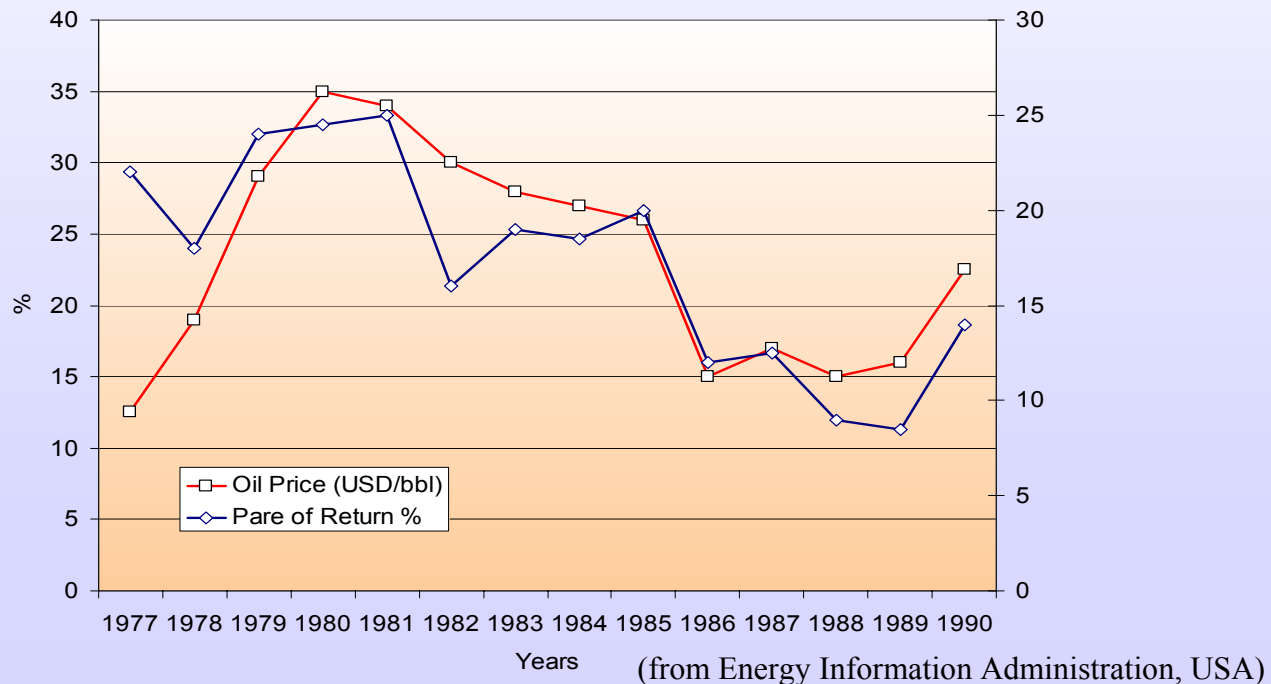
- Nationalisation
 - Not illegal after international law
 - Company gets compensation
- Policy and Rule Changes

Country Ratings



Oil Price - the only relevant Risk?

- The ROR for international Oil companies follows the oil price



Risk Management

- Risk Avoidance
 - Avoid opportunities with too large risk
- Loss Prevention
 - Understand and analyse the risk to prevent loss
- Risk Transfer
 - Farmouts, Joint Ventures, Diversification
- Insurance
 - Price dependant on risk
 - E.g. MIGA
 - » Currency Transfer
 - » Expropriation
 - » Breach of Contract
 - » War and Civil Disturbance



Decisions under Uncertainty



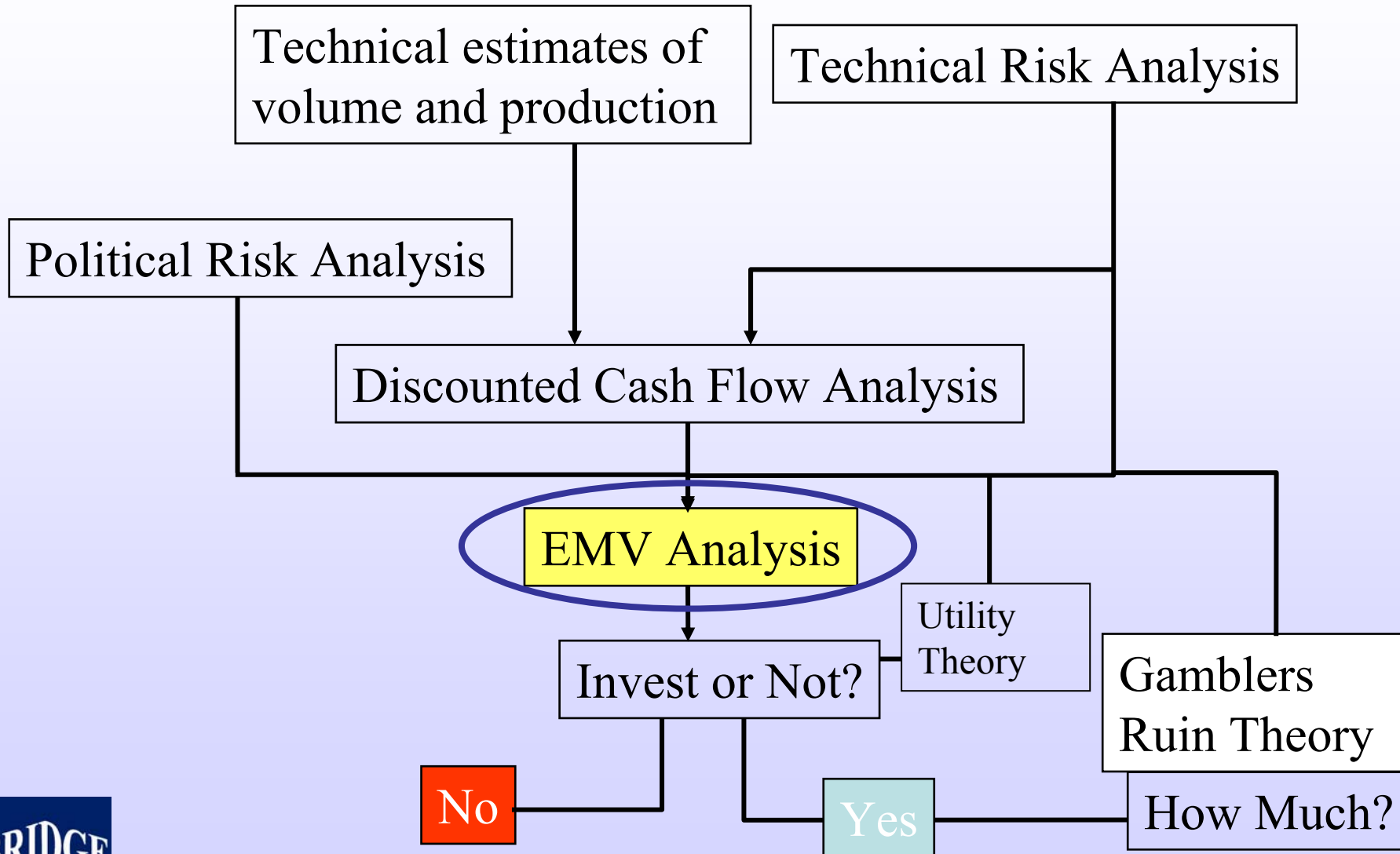
- The Consequences of a Decision is only unfolded in the uncertain Future
- Decision Analysis Methods are tools for manoeuvring in normal Business Environment

Decision Process



1. Understand Alternatives and the risk these alternatives involve
2. Evaluate the potential Consequences perceived in the Situation
3. Assess the uncertainties involved in the Decision
4. Recombining the judgements to develop a consistent Strategy

Risk Analysis Methods



Expected Monetary Value

- $EMV = (R * POS) - (RC * (1 - POS))$
 - EMV = Expected Monetary Value
 - R = Reward = Net Present Value (NPV)
 - POS = Probability of Success
 - RC = Risk Capital = Bonuses, Dry Hole Cost, G&G etc.

Total Success Probability

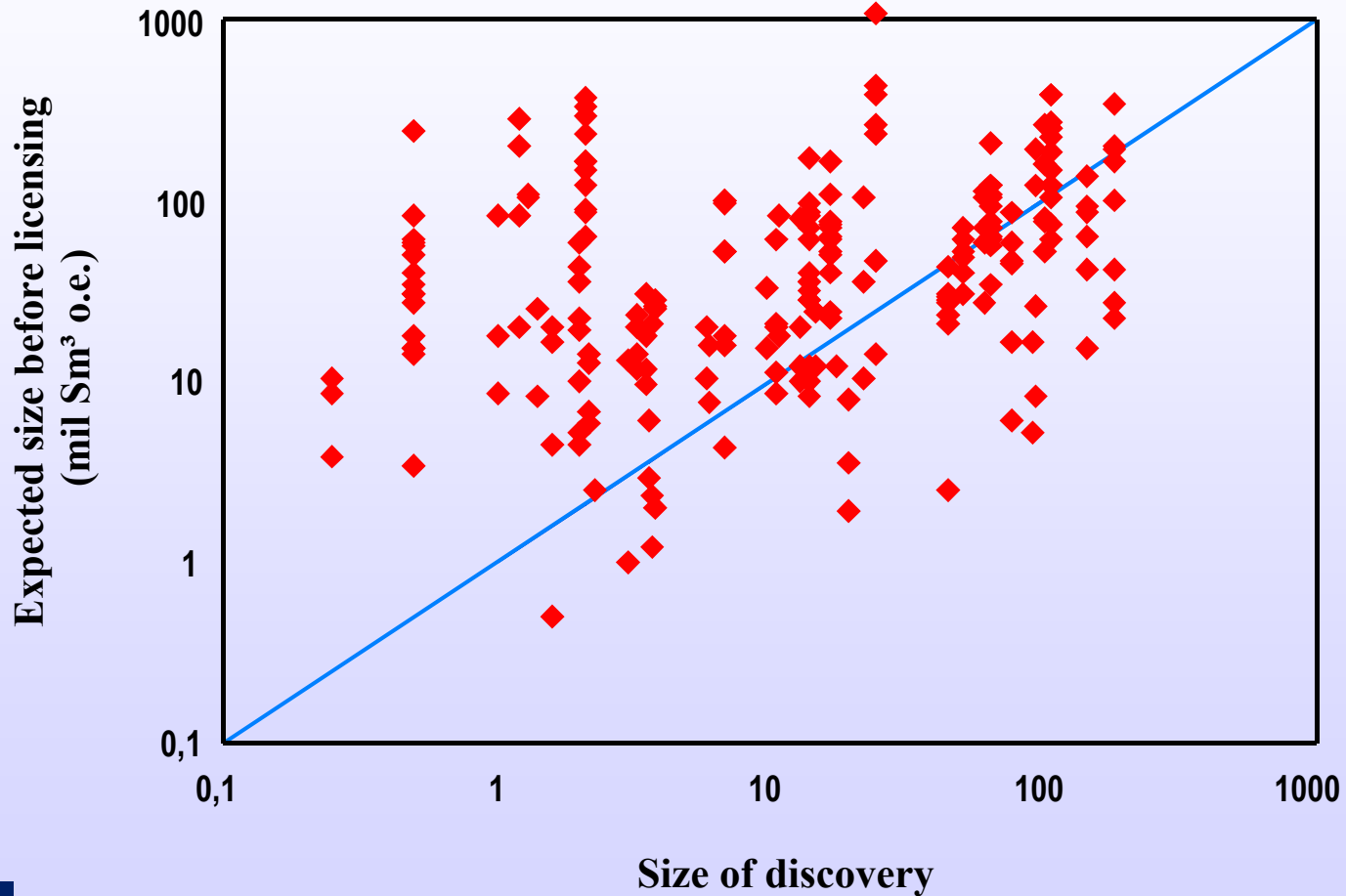
- $POS = P_{\text{expl.}} * P_{\text{dev.}} * P_{\text{fiscal}} * P_{\text{pol.}} * P_{\text{econ.}}$
- Example:
 - $POS = 0.5 * 0.9 * 1.0 * 0.8 * 0.6$
 - $POS = 0.22$

Geological risking

Initial risk assessment

Risk factor	P[play]	P[pros]	
Hydrocarbon source [%]	80.0		
Timing [%]	90.0		
Migration [%]	90.0		
Potential reservoir facies [%]	80.0		
Trap occurrence [%]		70.0	
Effective porosity [%]		80.0	
Hydrocarbon accumulation [%]		70.0	
> Marginal play probability [%]	51.8		
> Conditional prospect probability [%]		39.2	
> Unconditional probability [%]		20.3	
> Dry hole risk [%]		79.7	

Geological risk



From NPD

POS (Geological risk only)

Probability of success = 0.50

This is the typical probability of success of a step out or delineation well, or of an adjoining structure

Probability of success = 0.20 - 0.30

This is the typical range of probability of success of exploration in an area with many similar plays and structures and for an exploration well which is in such a structure not too far from existing discoveries

Probability of success = 0.10 - 0.20

This is the typical range of probability of success of exploration in a well explored area with a variety of different plays and on a new location

Probability of success = 0.02 - 0.05

This is the typical range of probability of success of exploration in a poorly explored area or a new geological basin in which previously no wells have been drilled or only dry holes have been drilled

EMV - Example

- Assumptions
- NPV = 120 million USD
- RC = 15 million USD
- POS = 22%

- $EMV = (R \cdot POS) - (RC \cdot (1 - POS))$
- $EMV = (120 \cdot 0.22) - (15 \cdot (1 - 0.22))$
- $EMV = 26.4 - 11.7$
- $EMV = 14.7$ million USD

- Break-even POS = $RC / (NPV + RC)$
- Break-even POS = $15 / (120 + 15)$
- Break even POS = 11.1% (EMV=0)

Success Capacity

- How many dry wells can a discovery carry?

$$\text{Success Capacity} = (1/\text{break-even success ratio}) - 1$$

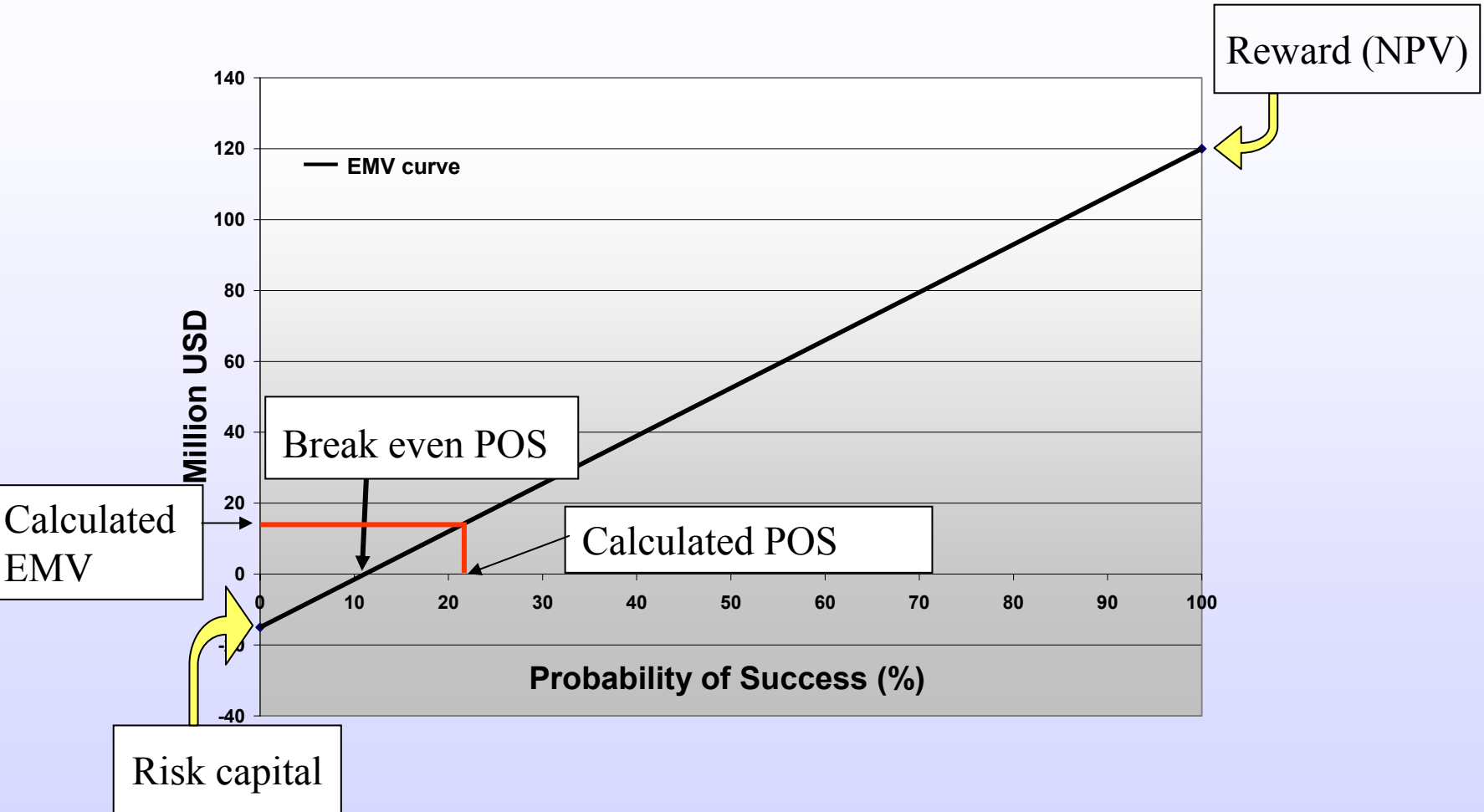
Example:

$$\text{Success Capacity} = (1/0.111) - 1$$

$$\text{Success Capacity} = 8$$

One success well can carry 8 dry wells and still have a positive NPV

EMV curve



EMV example

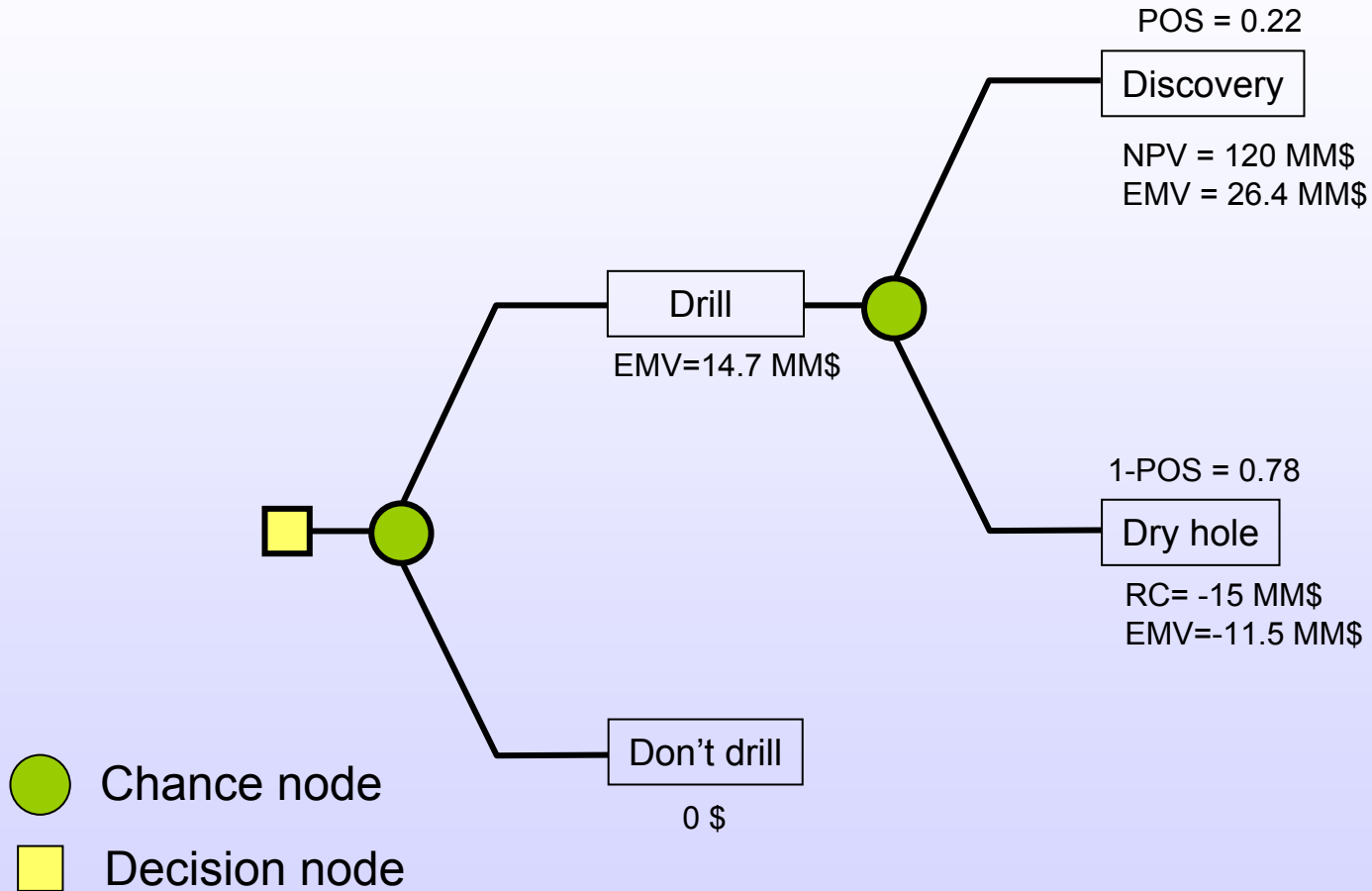
	Capital	POS	EMV
Outcome 1	120	22.0 %	26.4
1-POS	-15	78.0 %	-11.7
Total EMV			14.7

Break-even POS	11.1 %
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Success Capacity	8.0
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EMV Exercise

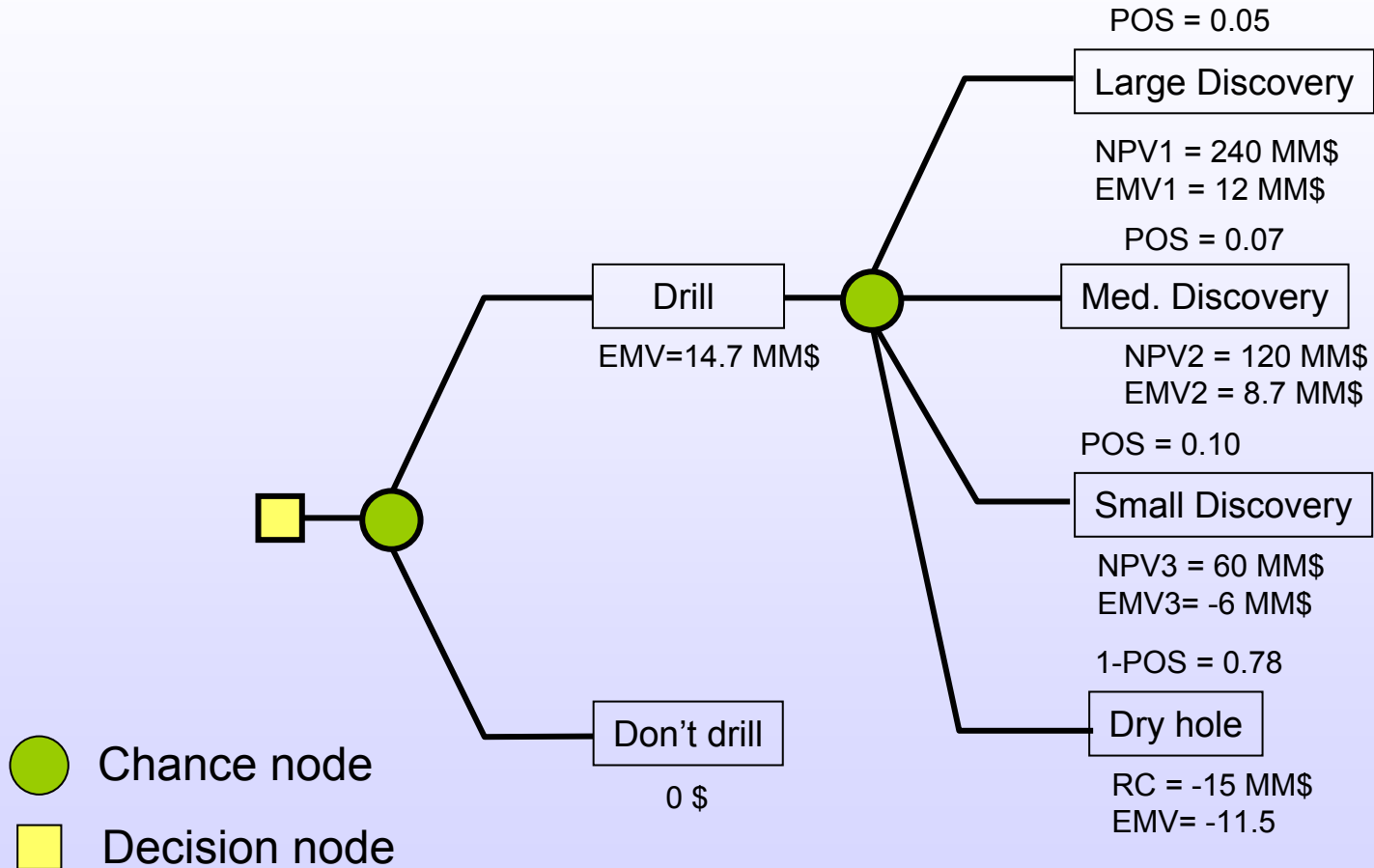
Two outcome decision tree



An expanded tree

	Capital	POS	EMV
Outcome 1	240	5.0 %	12
Outcome 2	120	7.0 %	8.4
Outcome 3	60	10.0 %	6
Total Capital	120	22.0 %	
1-POS	-15	78.0 %	-11.7
Total EMV			14.7

Multi outcome decision tree



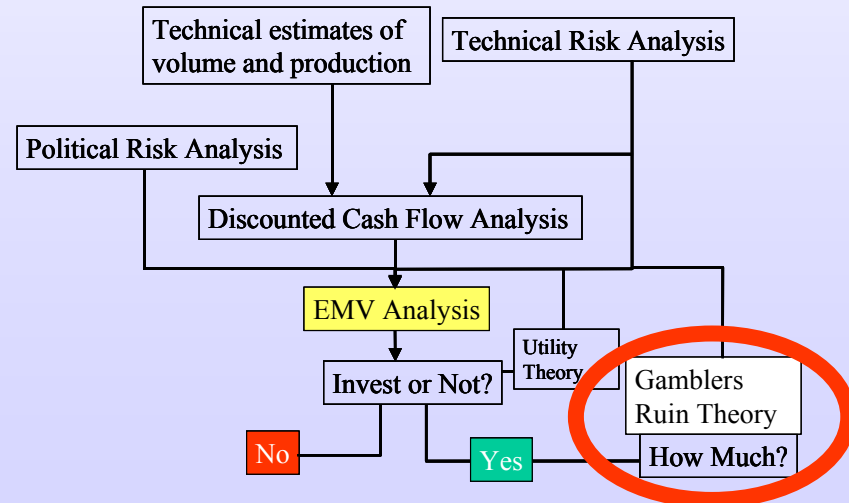
Total EMV = 14.7

Analyzing Political Risk

	Capital	POS	EMV
Discovery and moderate unrest	100	5.0 %	5.0
Discovery and large unrest	40	7.0 %	2.8
Expropriation during production	-60	10.0 %	-6.0
Unsuccessful Exploration	-15	78.0 %	-11.7
Total EMV			-9.9

Gambler Ruin Analysis

- Gamblers ruin occurs when a risk taker with a limited funds goes bankrupt due to continuous failures
- Will the company survive if worse come to worse



Probability of one success

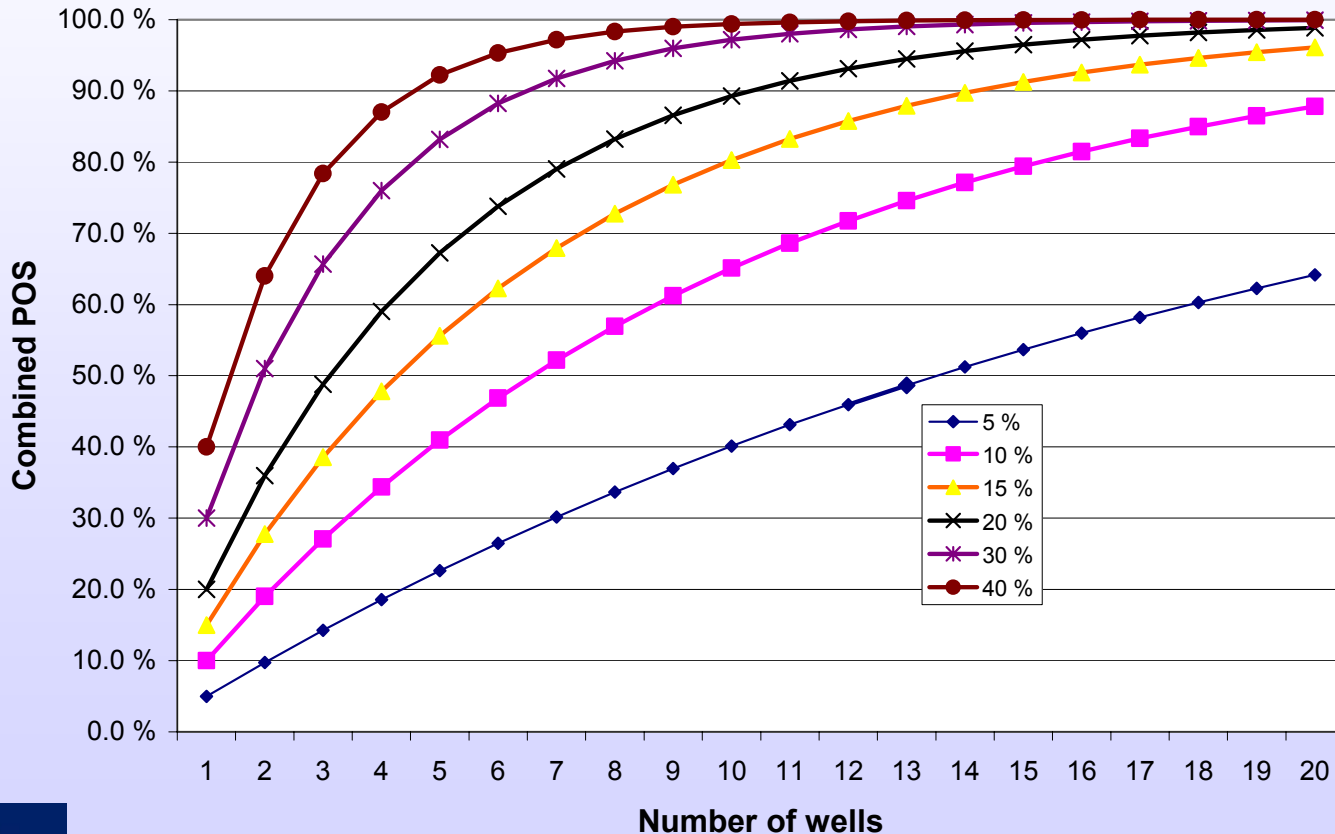
- What number of wells would be needed to be sure of at least one discovery at a certain confidence level

The probability of at least one success = 1 - the probability of all failures

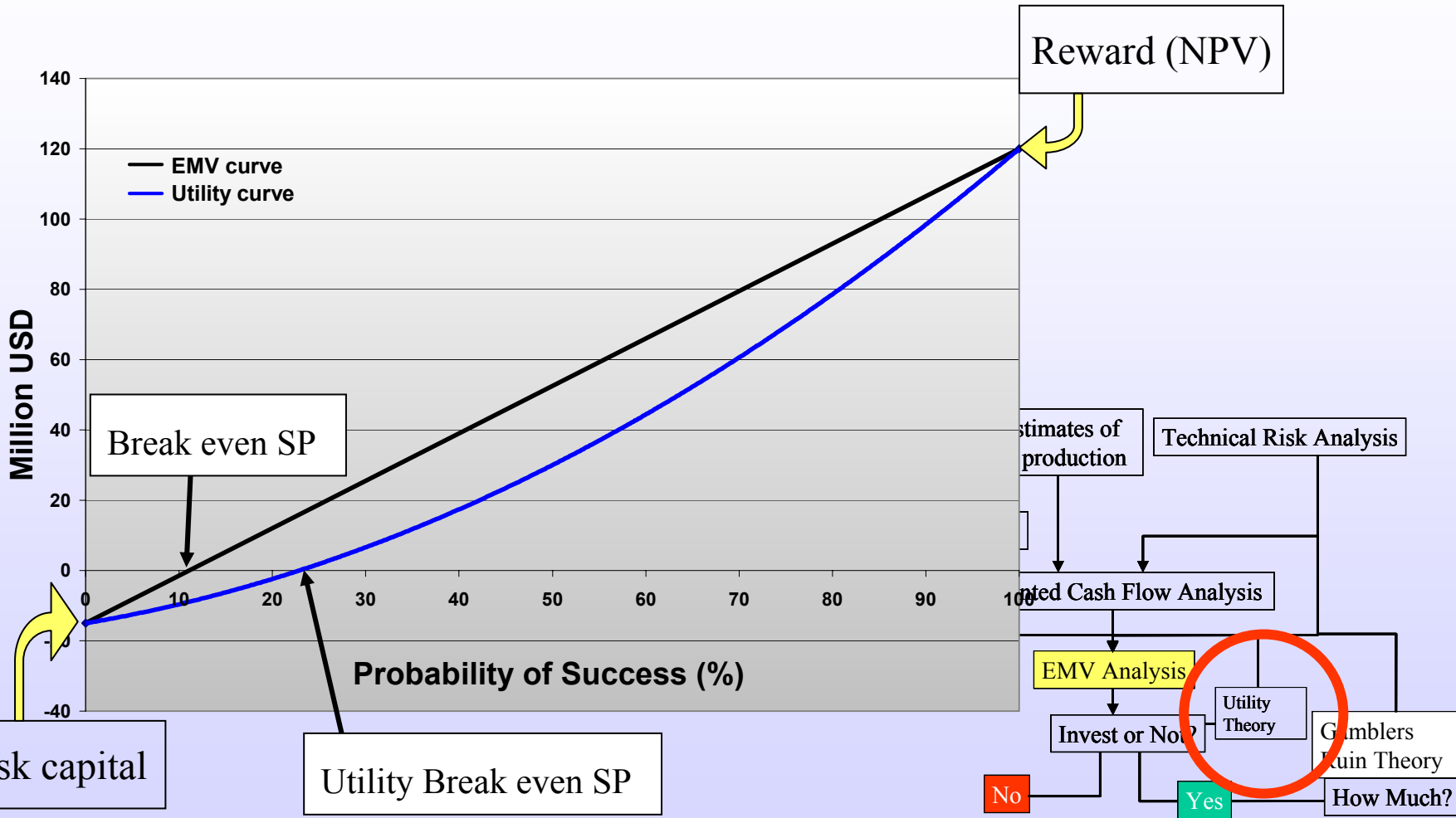
$$CL = 1 - (1 - POS)^n$$

CL = Desired confidence level
POS = Success probability
1-POS = probability of failure
n = No. of Exploration wells

Combined Probability of Success



Utility Theory



Risk capital

Utility Break even SP

EMV Exercise

- An oil company have mapped a prospect and concluded that the resources may be as high as 100 million barrels and the probability of success is estimated to 10%. The data acquired, the interpretations and the cost of the exploration well will amount to 20 million USD. If a discovery is made, the NPV will be 90 million USD.
- - Calculate the expected monetary value.
 - Find the break even POS
 - Will you recommend this project to your Management?
- The company decides to shoot a 3D seismic survey before the first well. The budget for the survey is 5 million. The structure is confirmed and estimated even bigger than before and the geologists now estimates the POS to 20% and the economists calculate an NPV of 120 million USD
 - What is the new EMV?
 - Was the decision to shoot the 3D correct?
 - How many dry wells can be drilled for the project to still be positive if a discovery is made?

Exercise B

	Capital	POS	EMV
Outcome 1	90	10.0 %	9
1-POS	-20	90.0 %	-18
Total EMV			-9.0

	Capital	POS	EMV
Outcome 1	120	20.0 %	24
1-POS	-25	80.0 %	-20
Total EMV			4.0

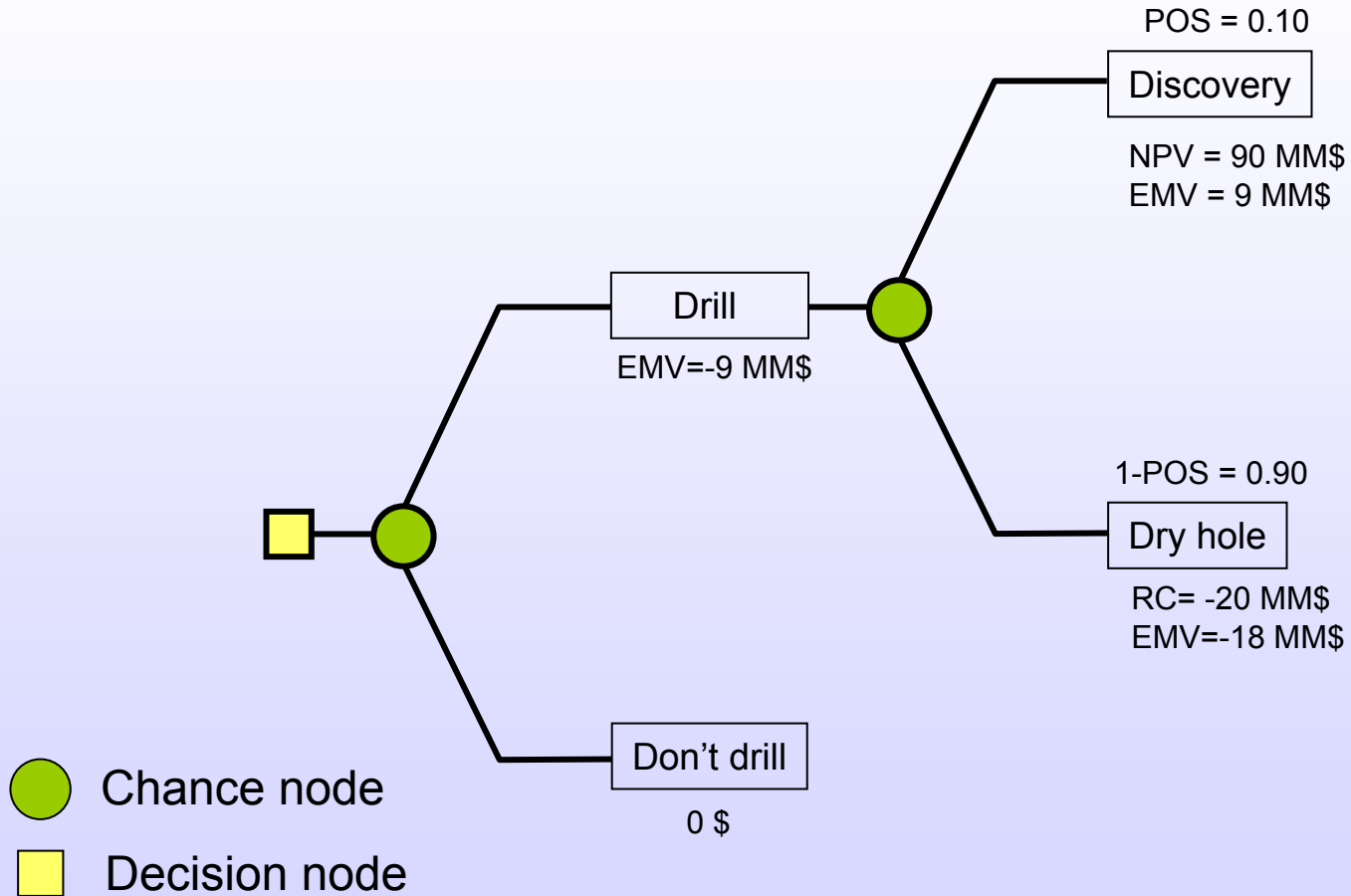
Break-even POS	16.7 %
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Break-even POS	17.2 %
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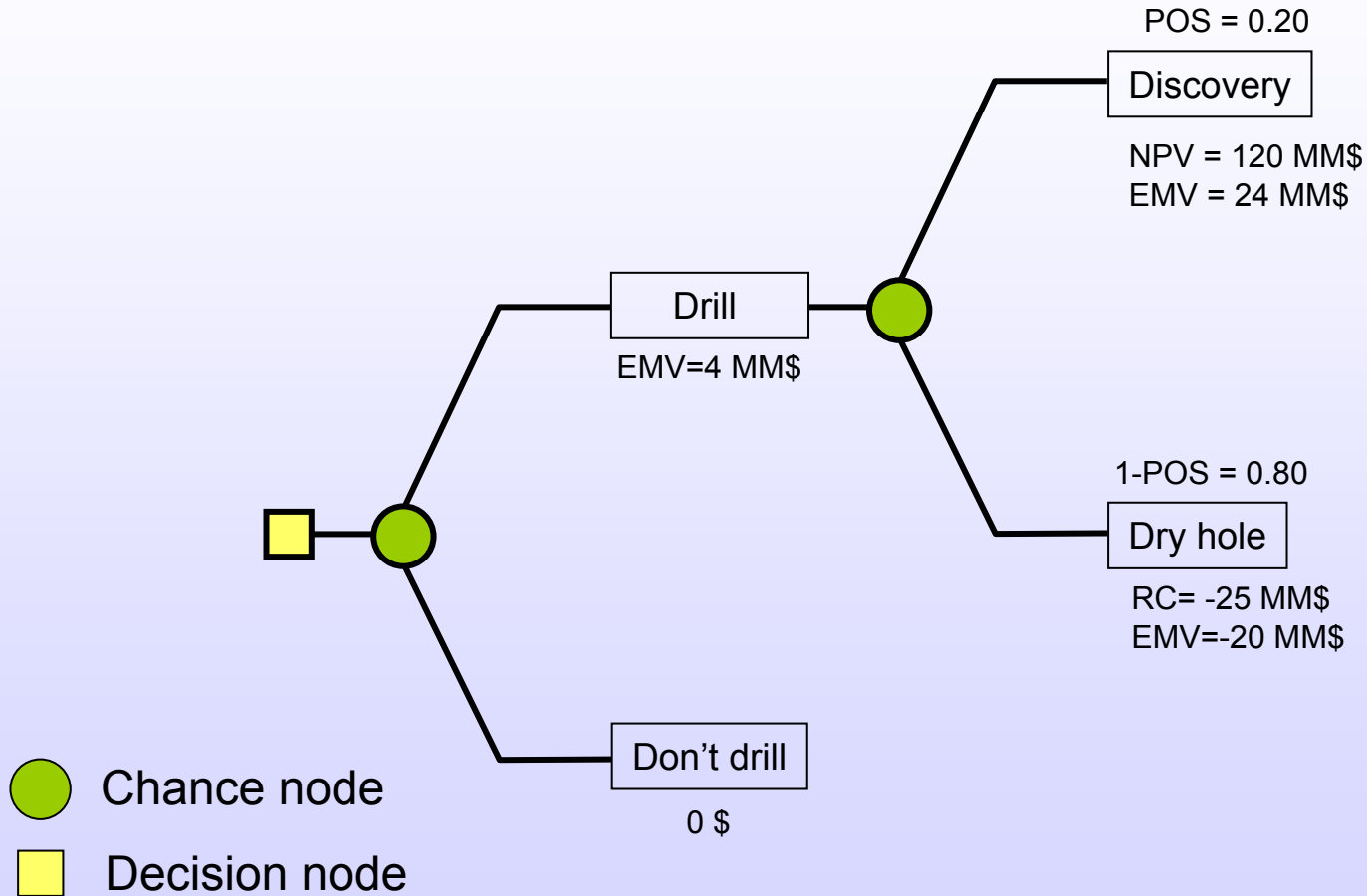
Sucess Capacity	5.0
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Sucess Capacity	4.8
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EMV Exercise without 3D



EMV Exercise with 3D



Multi outcome exercise

- An oil company has analyzed a prospect and have concluded that there may be three possible outcomes with related probabilities as given to the right in million usd
- The exploration cost is calculated to be 20 million usd
- Draw a multi branch decision tree which illustrates all outcomes
- Collapse the multi branch tree into a two branch tree and draw an illustration

	Capital	POS
Outcome 1	150	5.0 %
Outcome 2	100	10.0 %
Outcome 3	50	10.0 %

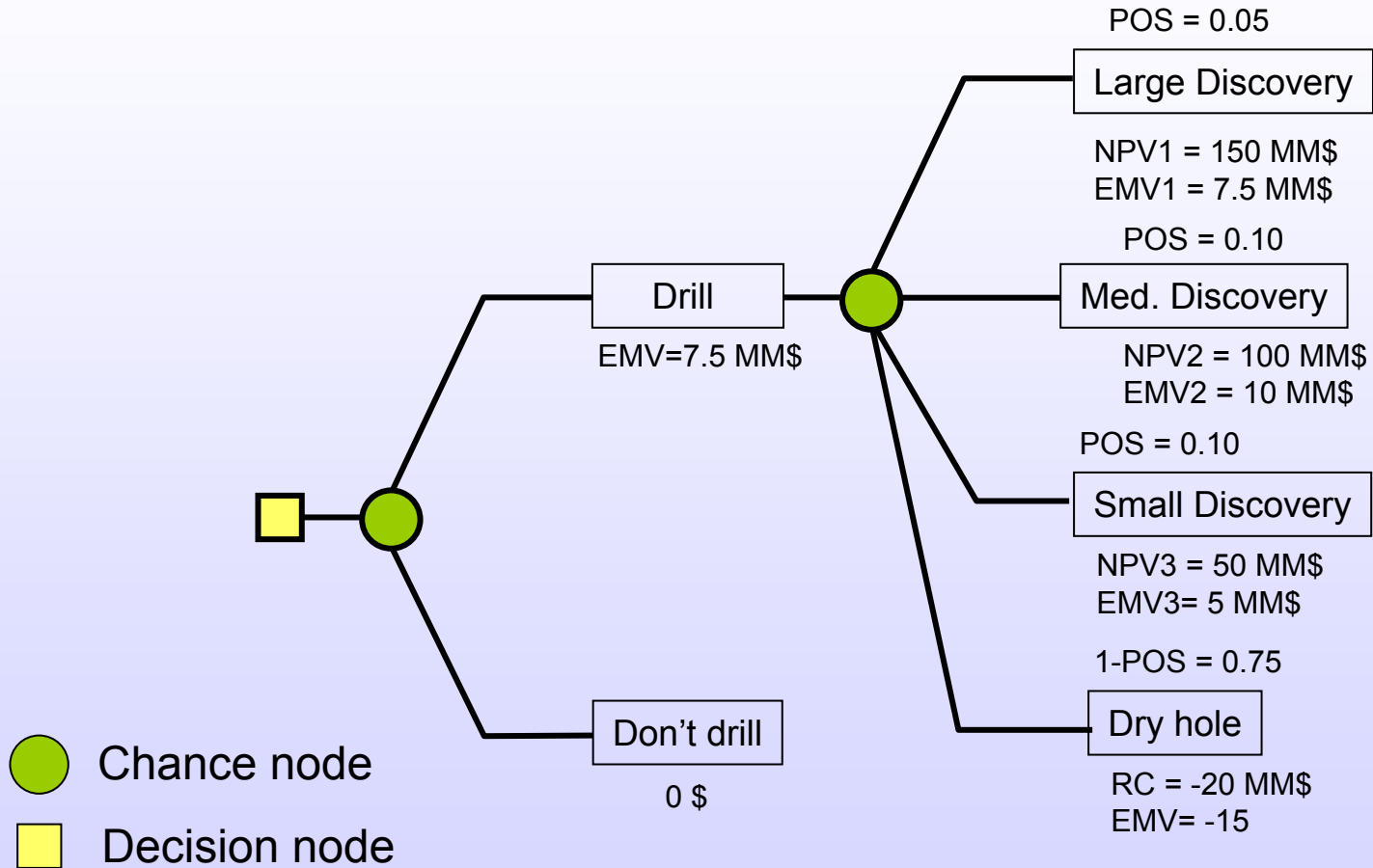
Multi outcome exercise

	Capital	POS	EMV
Outcome 1	150	5.0 %	7.5
Outcome 2	100	10.0 %	10
Outcome 3	50	10.0 %	5
Total Capital	90	25.0 %	
1-POS	-20	75.0 %	-15
Total EMV			7.5

Break-even POS	11.8 %
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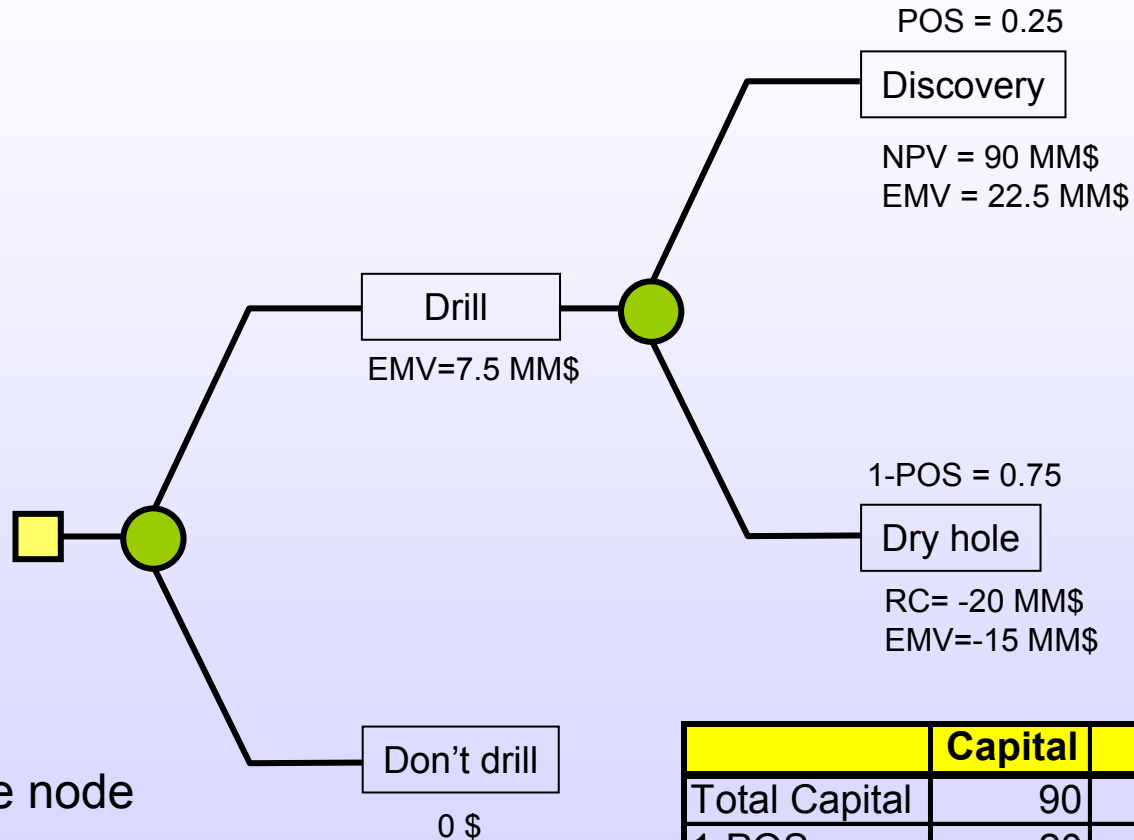
Success Capacity	7.5
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Multi outcome exercise



Total EMV = 7.5

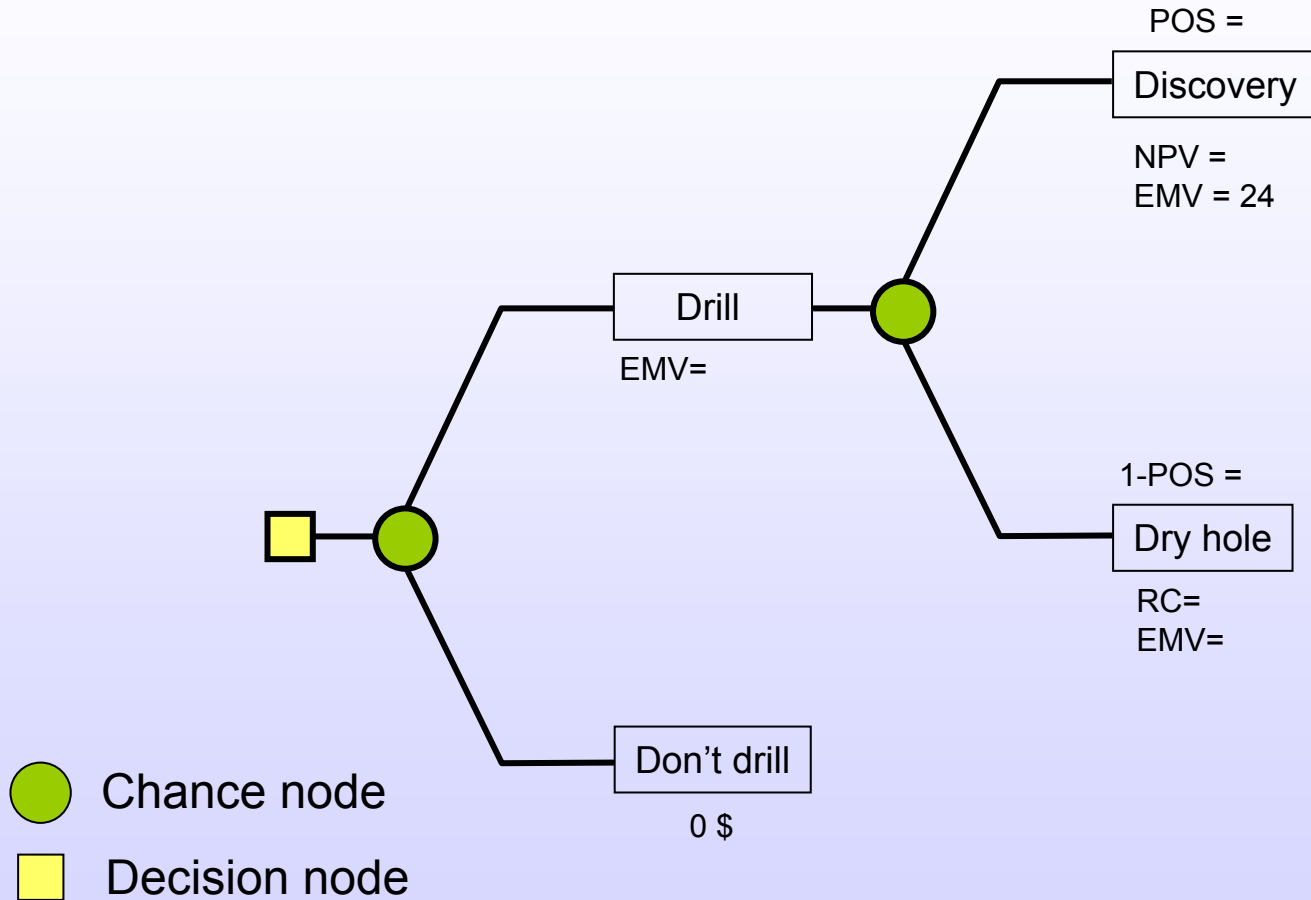
Collapsed multi-branched tree



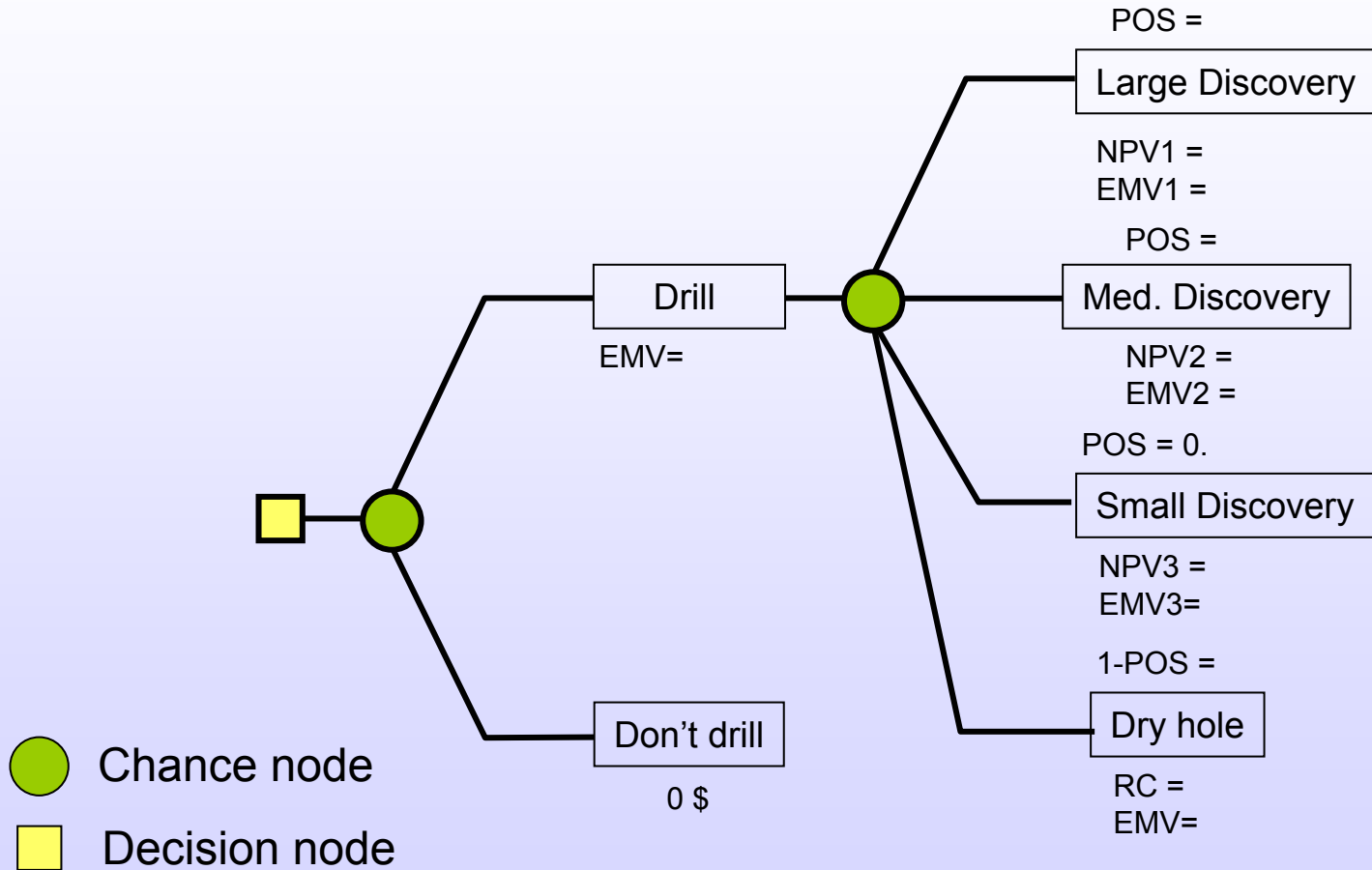
-  Chance node
-  Decision node

	Capital	POS	EMV
Total Capital	90	25.0 %	22.5
1-POS	-20	75.0 %	-15
Total EMV			7.5

Two outcome decision tree



Multi-branch decision tree



Total EMV = 7.5