Economic Risk and Decision Analysis for Oil and Gas Industry CE81.9008

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By
Dr. Thitisak Boonpramote

Department of Mining and Petroleum Engineering, Chulalongkorn University

http://pioneer.netserv.chula.ac.th/~btitisak/AIT_EconRisk.htm

Objectives

- To provide concepts of decision analysis use in E&P business such as decision tree analysis, value of information, risk preferences, certainty equivalent and real option valuation.
- To provide the basic knowledge of applying quantitative risk analysis particularly the geological risk in the upstream oil and gas business.

Reference Book:

- **Main Reference:**
  - M.A. Mian: Project Economics and Decision Analysis, Vol: 2, PennWell Corp., 2002.
  - P. Newendorp and J. Schuyer: Decision Analysis for Petroleum Exploration, 2nd. Edition, Planning Press, 2000.

- **Additional Readings:**
  - Selected papers from the course website.
  - I. Lerche and J.A. MacKay: Economic Risk in Hydrocarbon Exploration, Academic Press. 1993.
  - J. Mun: Real Options Analysis: Tools and Techniques for Valuing Strategic Investments and Decisions, John Wiley&Sons Inc., 2002.
  - T. Copeland and V. Antikarov: Real Options: A Practitioner's Guide, Texere Publishing Ltd., 2001.
  - A.K. Dixit and R.S. Pindyck: Investment under Uncertainty, Princeton University Press, 1994.

Project Valuation Methodology

Review of DCF Analysis

- **Basic steps**
  - Forecast the project's **expected future cash flows**
  - Determine an **appropriate discount rate** that accounts for the project risk and the time value of money
  - Determine the **Present Value** of project
  - Subtract cost of implementing the project (Investment cost) to arrive at the **NPV**
  - If **NPV > 0** invest in project.

Valuing Projects

- **How would we traditionally value projects?**
  - **Estimate future Cash Flows**

    Future Cash flows are uncertain, use **Expected Values**
  - **Estimate the Discount Rate**

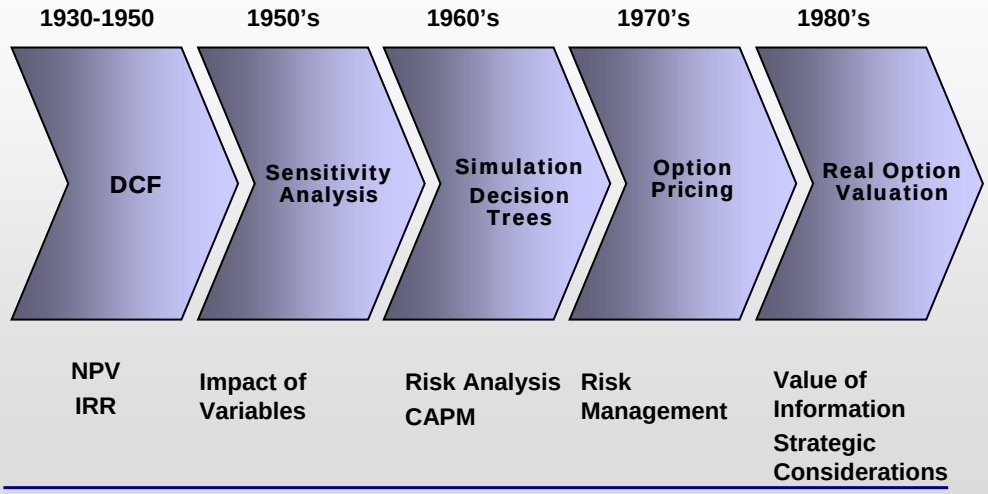
    Where does the discount rate come from?
  - **How to we deal with Risk?**

    Discount Rate, Scenarios, Sensitivity Analysis, etc.

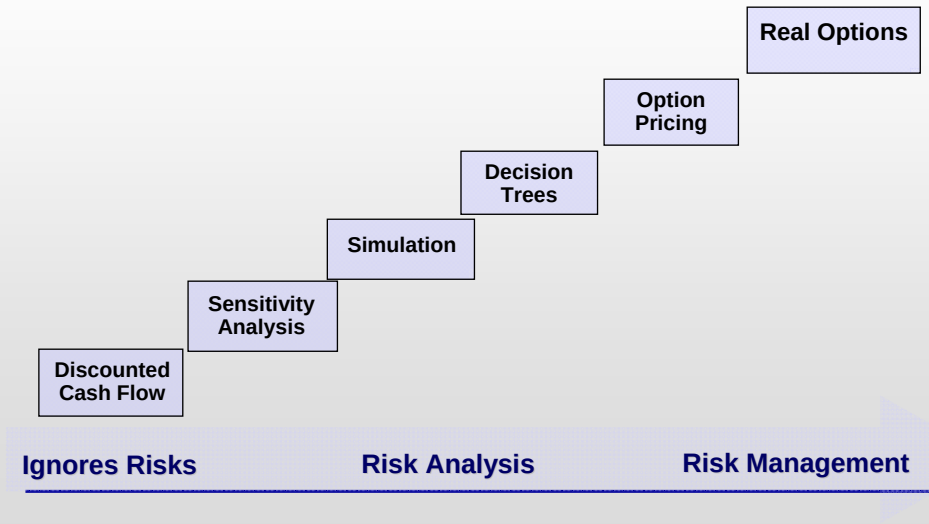
Evolution of Valuation Methods

- **DCF analysis** was introduced in ***the 1950's*** and first applied to petrochemical projects.
- Prior to that the **Payback method** prevailed.
- **Sensitivity and Scenario analysis** were developed at the US Air Force and the first corporate use occurred at Shell later in that decade.
- The advent of computers brought **simulation methods** in ***the 1960's*** and **decision trees**.
- **Option theory** was developed in **1973**, and **applications to real assets** occurred a few years later.

Evolution of Valuation Methods



Tools for dealing with Risk



The Capital Budgeting Decision

- Traditional Capital Budgeting involves the use of **Discounted Cash Flow (DCF)** methods
- DCF method was originally developed to value **financial investments** such as stocks and bonds.
- These financial assets are **passive** in nature as holders cannot typically influence their return.
- **Real assets** also have other characteristics that restrict the effectiveness of DCF methods

Financial vs. Real Assets

Financial Assets	Real Assets	Comments
Divisibility	Indivisibility	Projects are not divisible, value of control
High Liquidity	Low Liquidity	Implies higher risk
Low Transaction Cost	High Transaction Cost	Violates CAPM
Widespread information	Asymmetry of information	Allows arbitrage gains
Markets	No Markets	No market price
Market Risk	Market and Private Risk	Private risks not correlated with Market
Short Term	Long Term	Time to expiration
Passively Managed	Actively Managed	Value of Flexibility

Introduction to Decision Analysis

Introduction

- The objective of the **decision making process** is to make the **best decision** considering all **relevant factors** and **information** available at the time.
- However, **under uncertainty**, **good decisions** may lead to **bad outcomes** due to **chance** of unforeseen events.
- Thus it is important to make a distinction between **good decisions** and **good outcomes.**

Good Decisions vs. Good Outcome

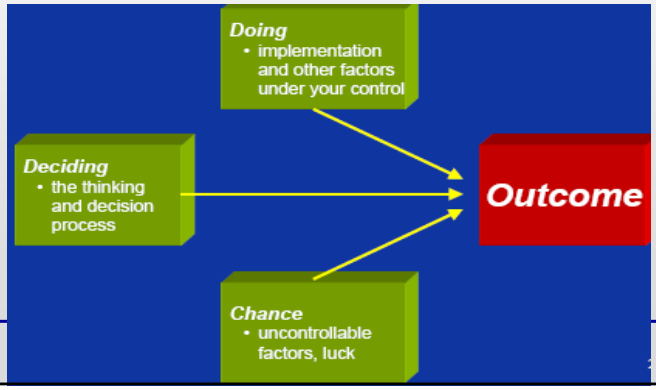
- The weather report on the evening news predicts a warm, dry sunny day tomorrow
- When you get up and look out the window in the morning there's not a cloud in sight
- You decide to leave your umbrella at home
- You get soaked in an unexpected afternoon thundershower

Did you make a bad decision?

Factors affect Decision Outcome

Decision outcome is influenced by three factors:

- **Deciding**: the thinking and ***decision process***
- **Doing**: implementation and other ***factors under your control***
- **Chance**: ***uncontrollable factors***, luck



Distinguish between decision and outcome

- **A good outcome** is a future state of the world that we prize relative to other possibilities.
- **A good decision** is an action we take that is logically consistent with the alternatives we perceive, the information we have, and the preferences we feel.
- The **quality of decision** should be judges by the **knowledge and information available** at the time the decision was made **not** the **outcome**.

Illusion of Control

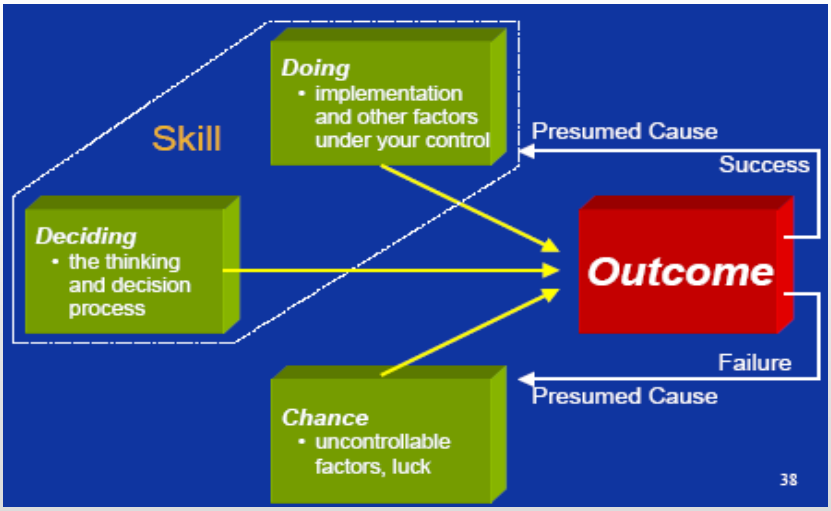
People often (knowingly and unknowingly) take credit for positive outcomes and attribute negative outcomes to external factors, no matter what their true cause.

Study of letters to shareholders:

- Executives tend to attribute favourable outcomes to factors under their control, and
- Unfavourable outcomes were more likely to be attributed to uncontrollable external events such as weather or inflation.

"Victory has a thousand fathers; defeat is an orphan." -the Duke of Wellington

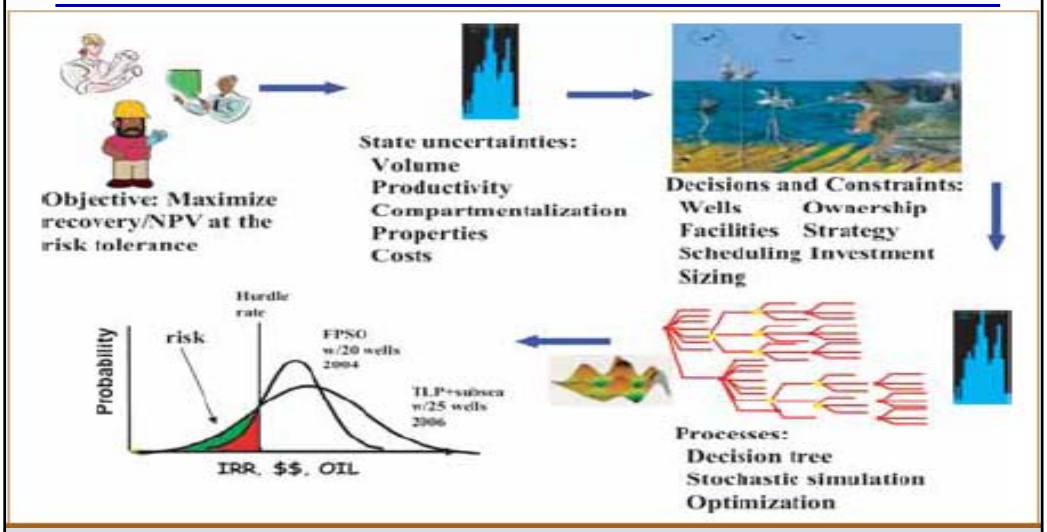
Illusion of Control



Illusion of Control

Illusion of control frequently cause people to repeat actions that in the past were followed by success.
This is true even if there's no reason to believe the actions did anything to cause the success.
Only by realistically assessing the role of chance in successes can you learn which of your actions you should repeat and which could be improved.

Decision processes with uncertainty to manage value and risk



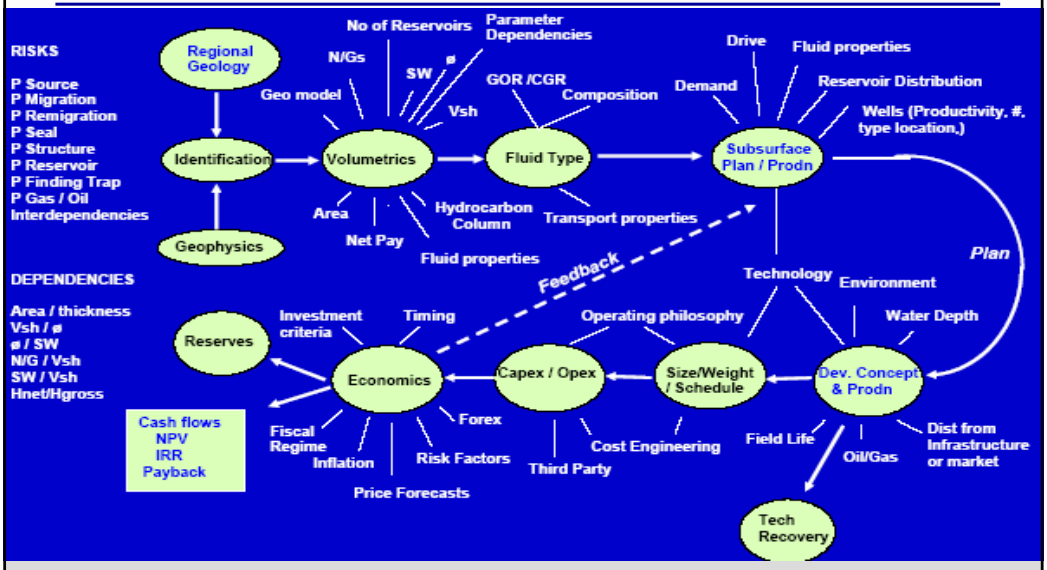
FPSO=floating production,storage and offloading vessel; TLP= tension-leg platform.

Decision Analysis Framework

- A formal framework for analyzing **decision problems that involve uncertainty** includes:
  - **Criteria** for choosing among alternatives.
  - How to use **probabilities**.
  - Analyzing how **early stage decisions** can affect future decisions.
  - How to quantify the **value of information**.
  - How to model **managerial flexibility**
  - How to graphically display a decision model using **Decision Trees**.

Risk & Uncertainty

Traditional Risk & Uncertainties in E&P

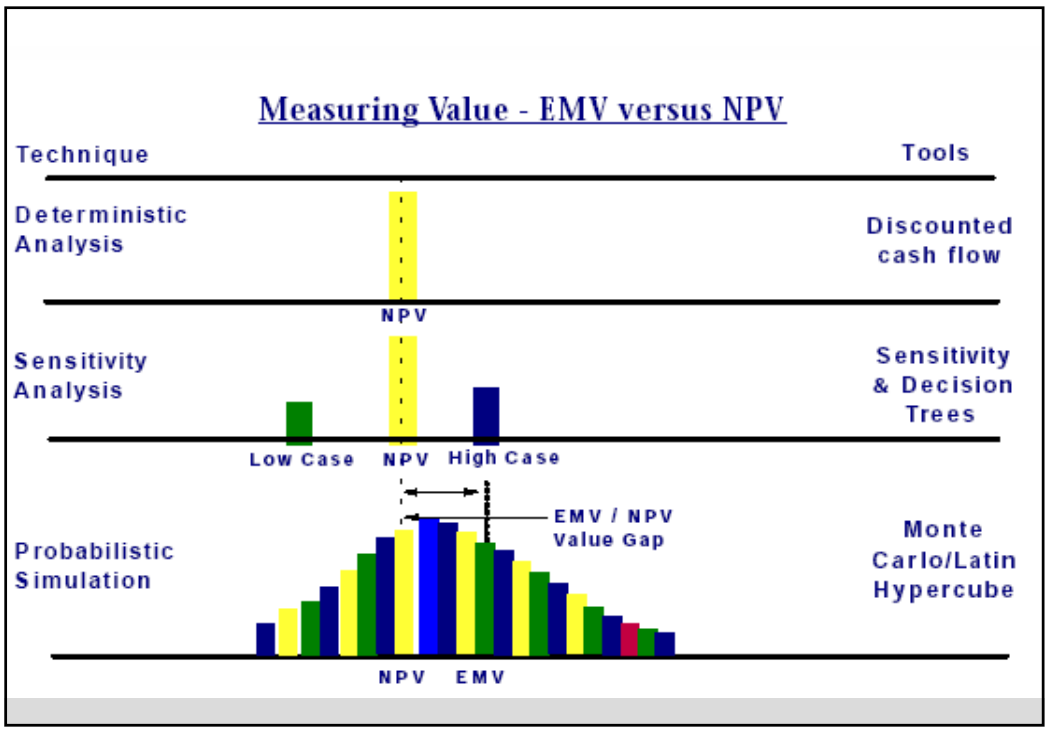


Step toward Risk

- Must decide the following:
  - Analysis under **certainty (point estimates)**;
  - Analysis under **risk:**
    - Assign **probability values** or **distributions** to the specified parameters;
    - Account for **variances**;
    - Which of the parameters are to be **probabilistic** and which are to be treated as "**certain**" to occur?

Which Procedure – Deterministic or Probabilistic?

- Features of probabilistic procedures
  - Identify **upside potential** and **downside risk**
  - **Quantify uncertainty**
- **Probabilistic procedures** more appropriate than deterministic when uncertainty is large and monetary risk is high
- **Deterministic methods** more appropriate for fully developed reservoirs with few expectations of significant additional investment



Uncertainty & Risk

The MIT dictionary of modern economics [1992] defines uncertainty as:

- "A situation in which the likelihood of an event occuring is not known at all. That is, no probability distribution can be attached to the outcomes ..."

and risk as:

- "A context in which an event occurs with some probability or where the size of the event has a probability distribution ..."

Decision Making under Uncertainty vs. Risk

Under uncertainty

- There are only two or more **observable values**;
- However, it is **most difficult to assign the probability of occurrence** of the possible outcomes;
- At times, no one is even willing to try to assign probabilities to the possible outcomes.

Decision Making under Uncertainty vs. Risk

Under risk

- The process of incorporating **explicitly random variation** in the estimates of measure of merit for an investment proposal
- Initial investments, operating expenses, revenues, field life, and other economic factors are seen as **random variables**

- **Risk** is associated with knowing the following about a parameter:
  - The number of **observable values** and,
  - The **probability** of each value occurring.
  - The **"state of nature"** of the process is known at hand.

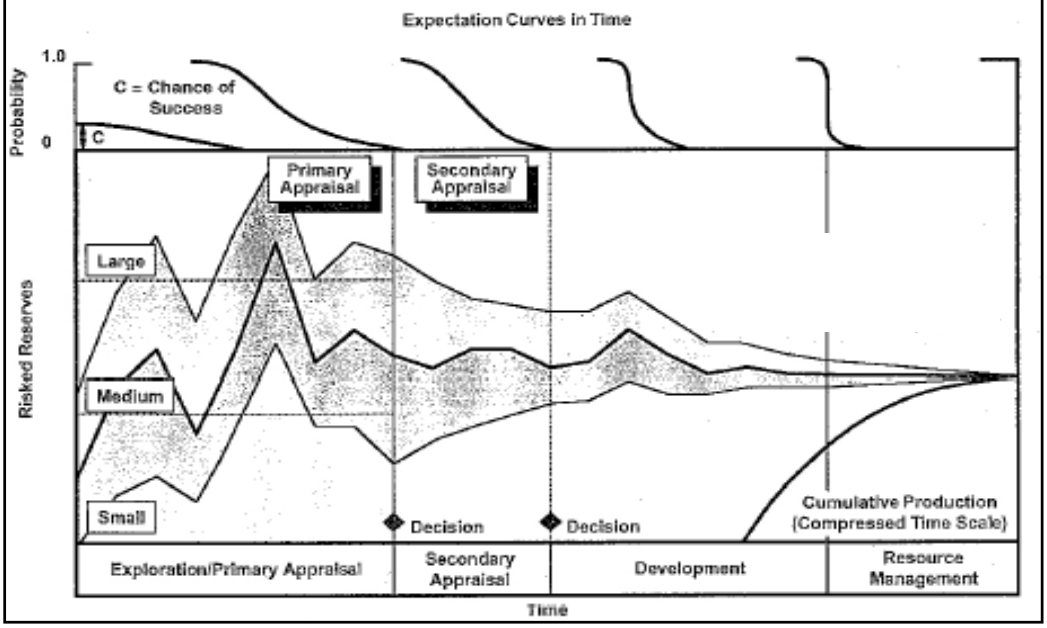
Risk

- The **chance** that the **cash flow** will **fall short** or **exceed** the **estimate** – **chance of loss**.
- **Sensitivity analysis** questions **the effect of cash flow deviations** and the cost of capital when risk is considered.
- **Risk analysis** is appropriate when **significant outcome variations** are likely for different future states and **meaningful probabilities** can be assigned to those states.

Risk Analysis

- Approaches:
  - **Expected value analysis**
    - Discrete or continuous?
    - Must **assign** or **assume** probabilities/probability distributions.
  - **Simulation Analysis**
    - Assign relevant **probability distributions**:
    - **Generate simulated data** by applying sampling techniques from the assumed distributions

Range of Recovery Estimates During the Life of a Field



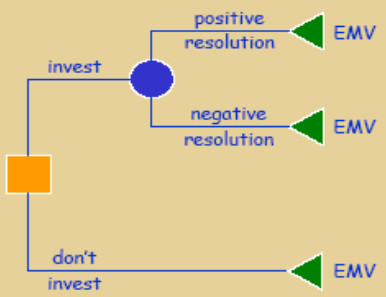
Comparisons Sources of Risk/Uncertainty

Characteristics	Economic uncertainty	Technical uncertainty
Example	• Price of oil	• Quantity of oil in an oil field
Value today	• Known with certainty	• Unknown, may have an estimate of the expected value with a variance around it
Change in value over time	• Future values unknown until future arrives	• True value does not change, but investing in learning can be used to improve estimates
Method for gaining additional information	• Waiting - mere passage of time	• Initiate learning project immediately (waiting alone will not bring new information)

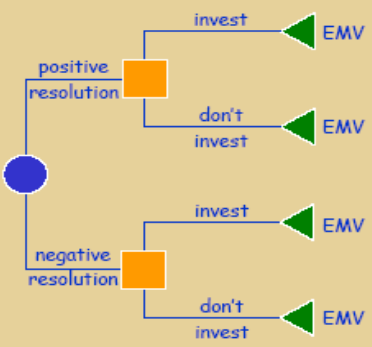
Comparisons Sources of Uncertainty

In the case of technical uncertainty, the only way to learn more about it is by actually undertaking the project. As a result one is still exposed to the outcomes of the uncertainty. Conversely, in the case of economic uncertainty, one would only make a decision whether to invest or not depending on the resolution of the uncertainty.

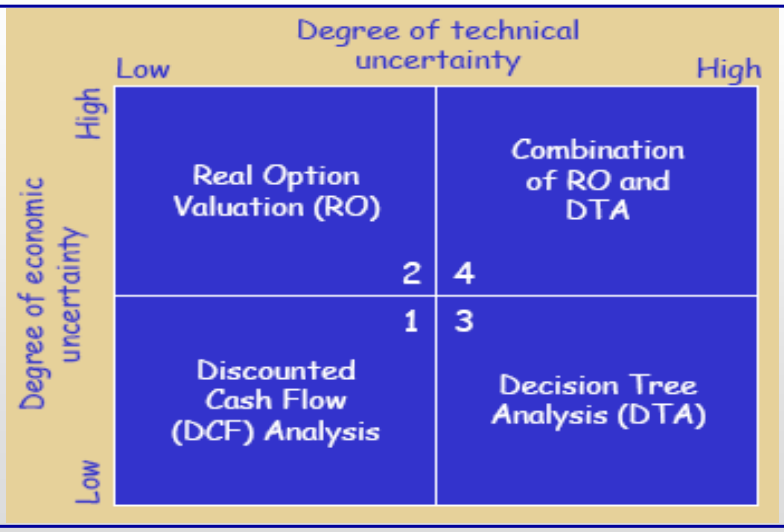
Technical uncertainty



Economic uncertainty



Optimal Valuation Selection



Examples of Uncertain, Risky Situations

- **Newly discovered offshore reservoirs** in sparsely developed areas, with significant capital expenditures required prior to development and production
- **Deep onshore reservoirs** in geologically complex areas, especially in high temperature, high pressure environments
- **Reservoirs where massive hydraulic fracturing required** for commercial production, frac costs substantial, results uncertain
- **Improved oil recovery projects**, especially where process has not been uniformly successful