DSC5211C QUANTITATIVE RISK MANAGEMENT

SESSION 1

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Introduction to Risk Analysis and Risk Attitudes

Objectives for Session 1

- Basic Concepts of Risk Analysis
- Introduction to:
    - The Concept of Uncertainty
    - The relation between Risk attitudes and Risk
    - Normative Approaches vs. Descriptive Analysis
    - Cognitive aspects in Risk Taking

Reading List:
   Vose, Ch. 1-8.

What is Risk?

- **Risk**: random event that may possibly occur and that has a *negative* impact on the goals of the decision maker.

- **Inherent Risks**: are the risk estimates before accounting for any mitigation efforts.

  - Ex.: the risk of a radio-active leakage before having an increase of capital.

Why Do a Risk Analysis?

- Understanding uncertainty helps us making better decisions.
  - To get a better insights into the problem analysed
  - To compare different options available to the decision maker
  - To structure the problem in a systematic way
  - To analyse possible alternatives to the decision under analysis.

- Risk is an important component of everyday life:
  - Credit Crunch (Credit risk, mortgages)
  - Bankruptcies (Enron)
  - Natural Events (earthquakes, floods)
  - Accidents.

- *It is impossible to Forecast, but you can Manage Risk.*

Risk and the Environment
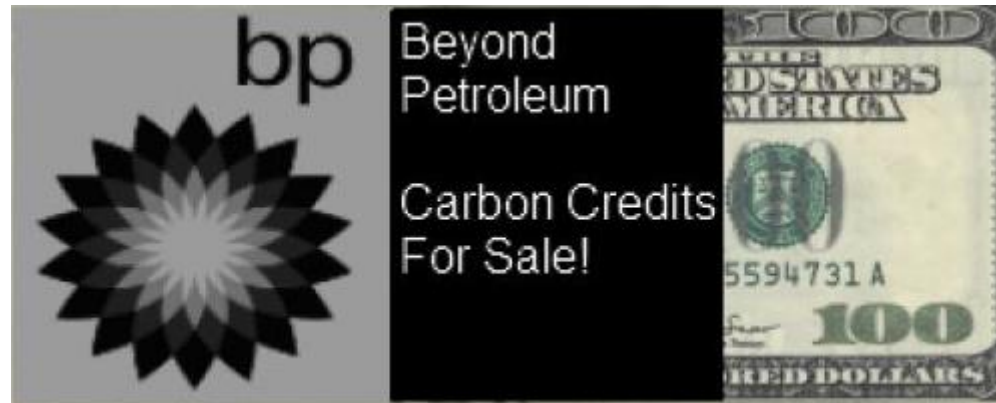
Typology of Risk Exposures

- Market Risk: negative impacts associated with the evolution of market prices and costs.

- Credit Risk: negative impact of a possible bankruptcy of a partner on its ability to repay its debt.

- Liquidity Risk: represents the negative impact of the type of assets a firm owns on its availability to generate cash-flow. A firm that cannot generate cash to pay its debts goes bankrupt.

- Operational Risk: possible losses resulting from inadequate systems, management failure, faulty controls, fraud and human errors.
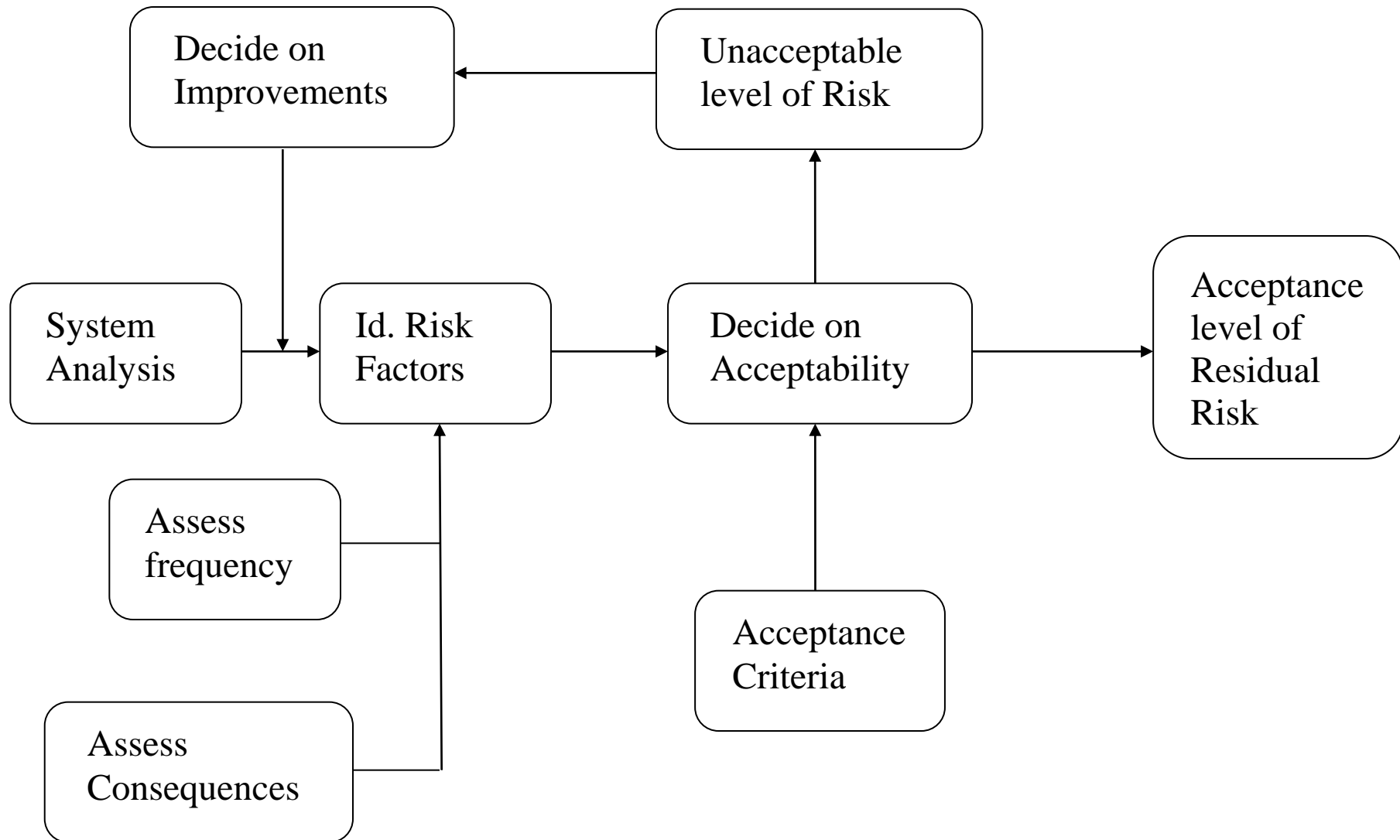
Typology of Risk Exposures (Cont.)

- Legal Risk: arises when the firm exposes itself to practices that are or may become illegal. It may also occur due to practices that are legal but can lead to losses for a partner or customer, who may demand compensation for any losses incurred.

- Human Factor Risk: These relate to any loss that may result from human error, including bad driving, typos in files, bad decisions, etc.

- Regulatory risk: in highly regulated industries the change in regulation can affect substantially the value of the firm. Examples: regulations on security of toys can make a toy illegal; the legalization of gas-fired electricity plants reduced the value of coal plants.

Risk Management – Main Problems

- ***Identification of all possible sources of problems***: what can go wrong with the project?

- ***Measurement of the possible negative impacts***: what is the range of magnitude of these adverse consequences?

- ***Define risk management options***: what can be done and at what cost to reduce unacceptable risk and damage?

Risk Assessment and Management

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Decide on            Unacceptable
Improvements  <----  level of Risk
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System   Id. Risk   Decide on   Acceptance
Analysis   Factors   Acceptability   level of
                                                     Residual
                                                     Risk

Assess
frequency

                             Acceptance
                             Criteria

Assess
Consequences

Managing Inherent Risks

	PROBABILITY	
High	Transfer (Catastrophe)	Avoid
Low	Accept	Control (Operations)
	Low	High

IMPACT

Choice of Model Structure

- **Decision Trees**: They represent the interaction between the decisions and the stochastic events influencing their possible outcomes.

- **Monte-Carlo Simulation**: models the impact of stochastic events on the objectives that the decision making is attempting to control. For example, these are applied to Poker, Option Pricing; Stock markets; Analysis of investments.

- **Stochastic Programming**: It aims to optimize decisions under uncertainty. As decision trees it models the interactions between decisions and the sources of uncertainty. It does not have a graphical representation.

Decision Tree - Nuclear Power Plant Location

- **Generation Cost:** 22 euros/MWh if plants is built on the coast line; 33 euros/MWh if plants is built in the country side.

- Revenue: 43 euros/MWh if there is no Tsunami. If there is a tsunami the revenue is zero if the plant is in the coastal area and 50 euros/MWh is it is in the country side.

- The probability that the nuclear power plant is hit by a Tsunami is 1% in any given year.
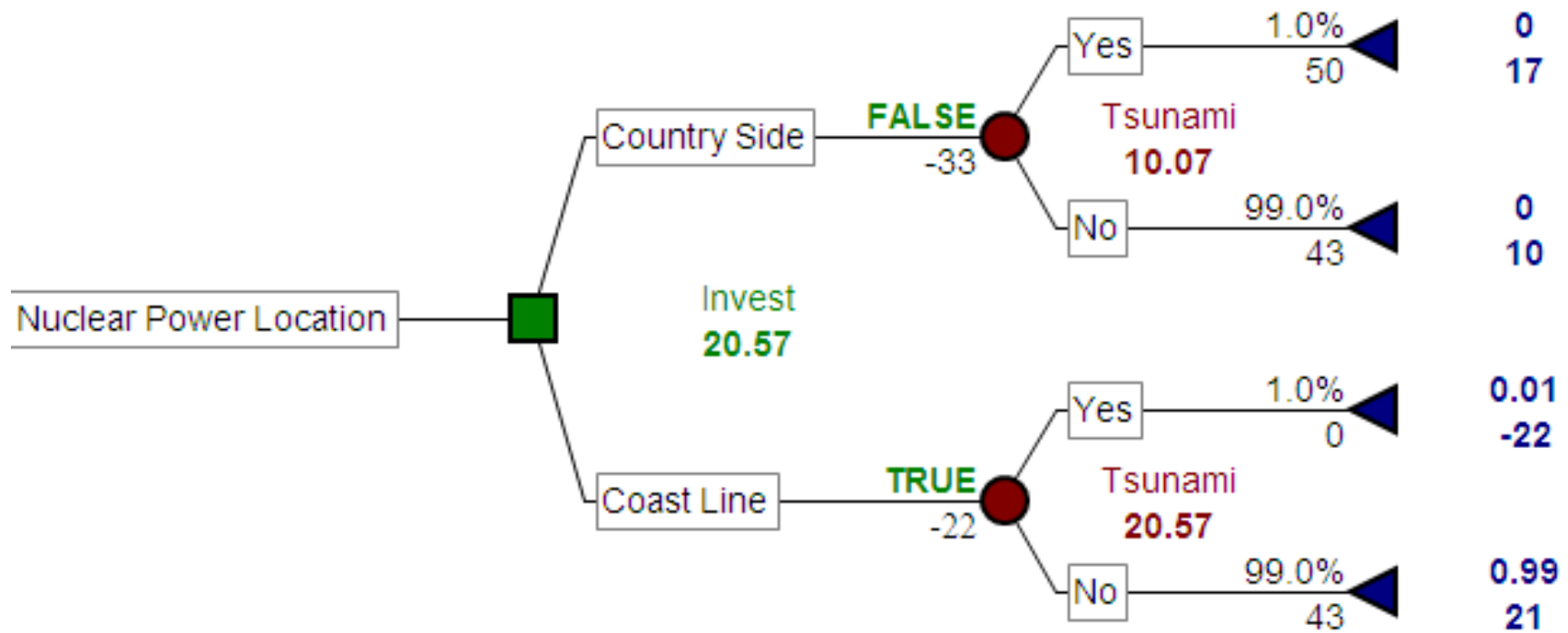
Decision Tree - Nuclear Power Plant Location

- Risk Neutral Decision – maximize expected value:

    - ***The Optimal Decision is to locate the plant near the coast.***

- Risk Averse Decision – minimize worst possible outcome:

   - ***The Optimal Decision is to locate the plant in the country side.***

The Role of Risk in Decision Making

- The classic treatment of risk in decision theory distinguishes among three types of decision-making situations (Luce and Raiffa, 1957):

  - Certainty – an action is known to lead invariably to a given outcome.
    Ex. Investment in a Long-term deposit.

  - Risk – an action leads to a few known outcomes, each of which occurs with a given probability.
    Ex. Flipping a coin.

  - Uncertainty – an action leads to a set of outcomes, however the probability of these is unknown.
   Ex. Investment in stocks

Normative Approaches to Risk

- The expected value rule: the decision maker maximizes (minimizes) the expected value as the *outcomes*, when analyzing choices under risk.

- The expected utility rule: the decision maker maximizes (minimizes) the expected value of its *utility*, when analyzing choices under risk.

- The utility takes into account the decision maker's risk attitudes:
    - Risk-neutral: the relationship between expected outcomes and expected utility is *linear*;
    - Risk-averse: the relationship between expected outcomes and expected utility is *concave*;
    - Risk-seeking: the relationship between expected outcomes and expected utility is *convex*;
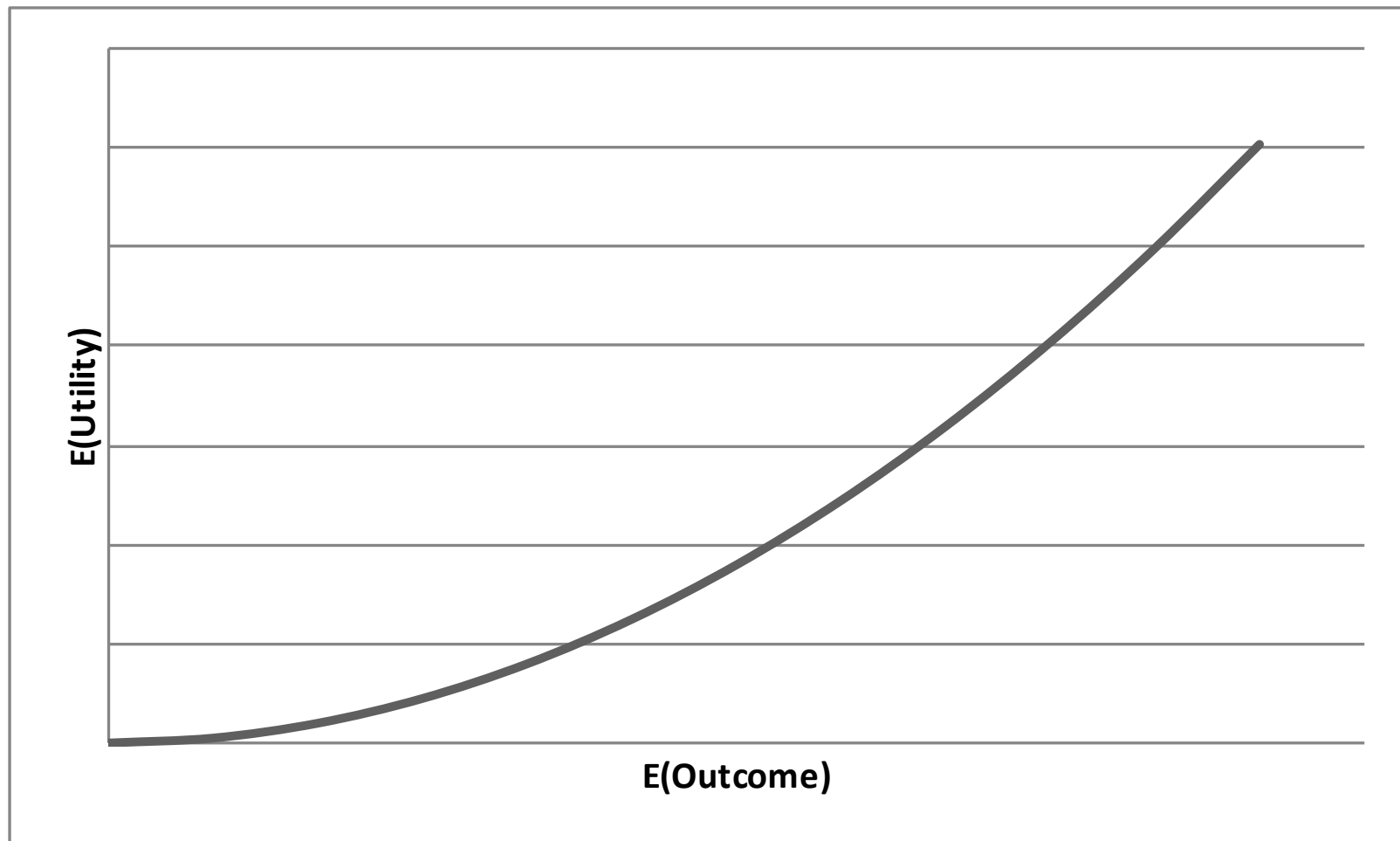
Risk-Neutral Decision Maker
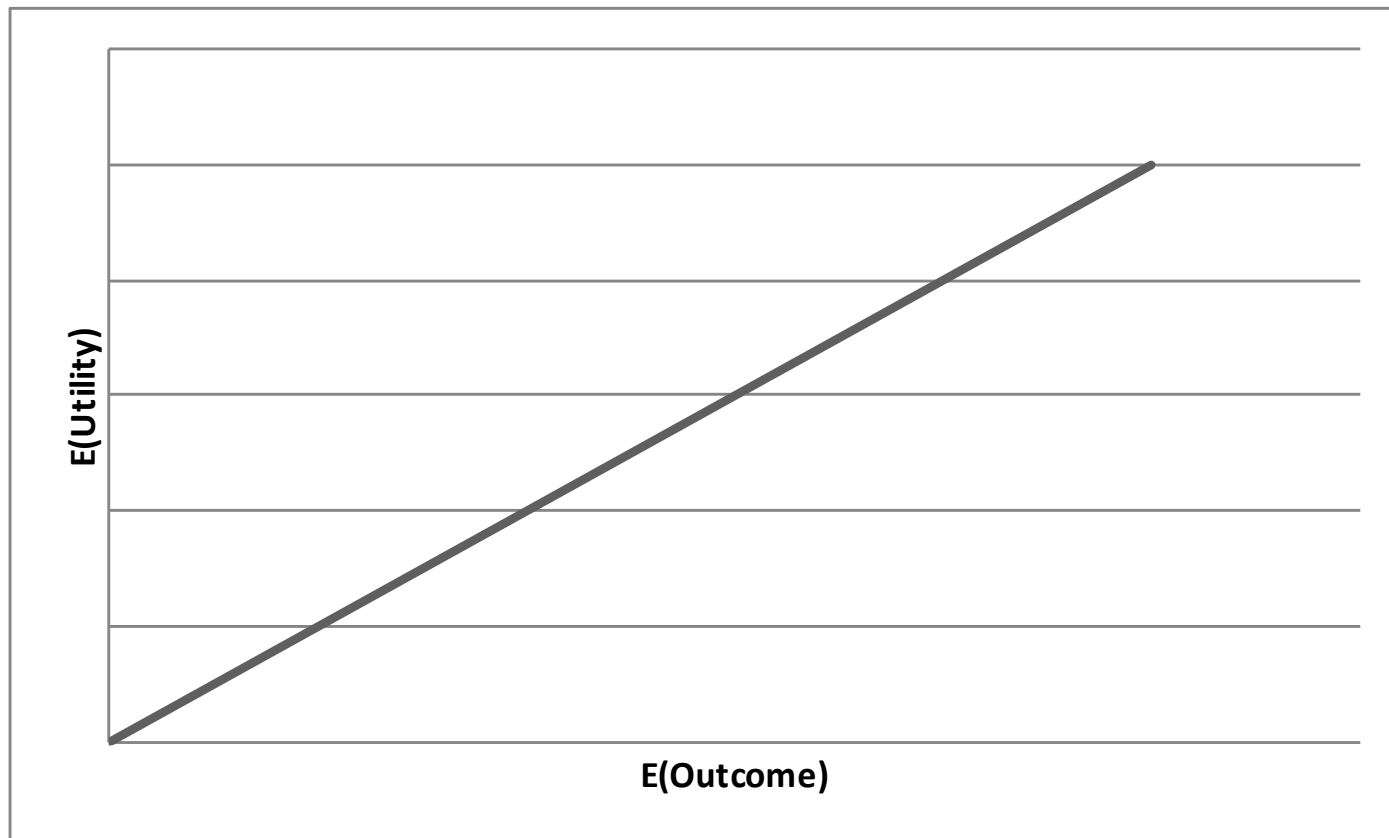
Risk-Averse Decision Maker


E(Utility) vs E(Outcome)
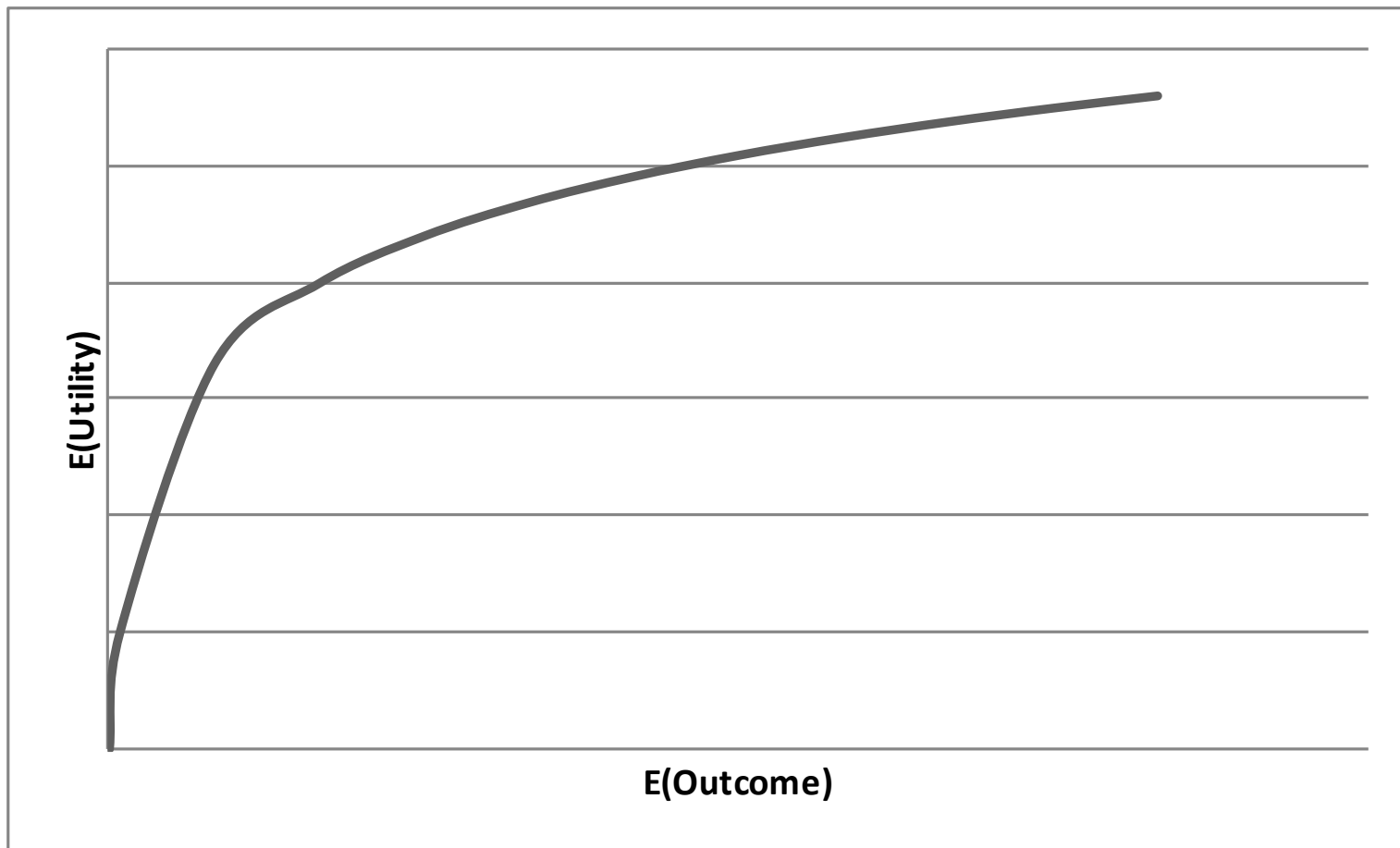
Risk-Seeking Decision Maker

Descriptive Approaches to Risk

- These are important when the amount of data involved in the decision making process is very large.

- The Satisficing Principle: The decision maker considers alternatives in only a subset of possible choices.
    - Therefore, the process does not necessarily lead to the optimal policy.
    - The decision maker searches for a best possible solution in a limited set of options.

- Prospect Theory: It starts from the observation that decision makers do not decide in the same way when facing a loss or a gain.
    - Decision makers are risk-averse in gain situations and risk-seeking in when facing possible losses.

Prospect Theory – Value Function
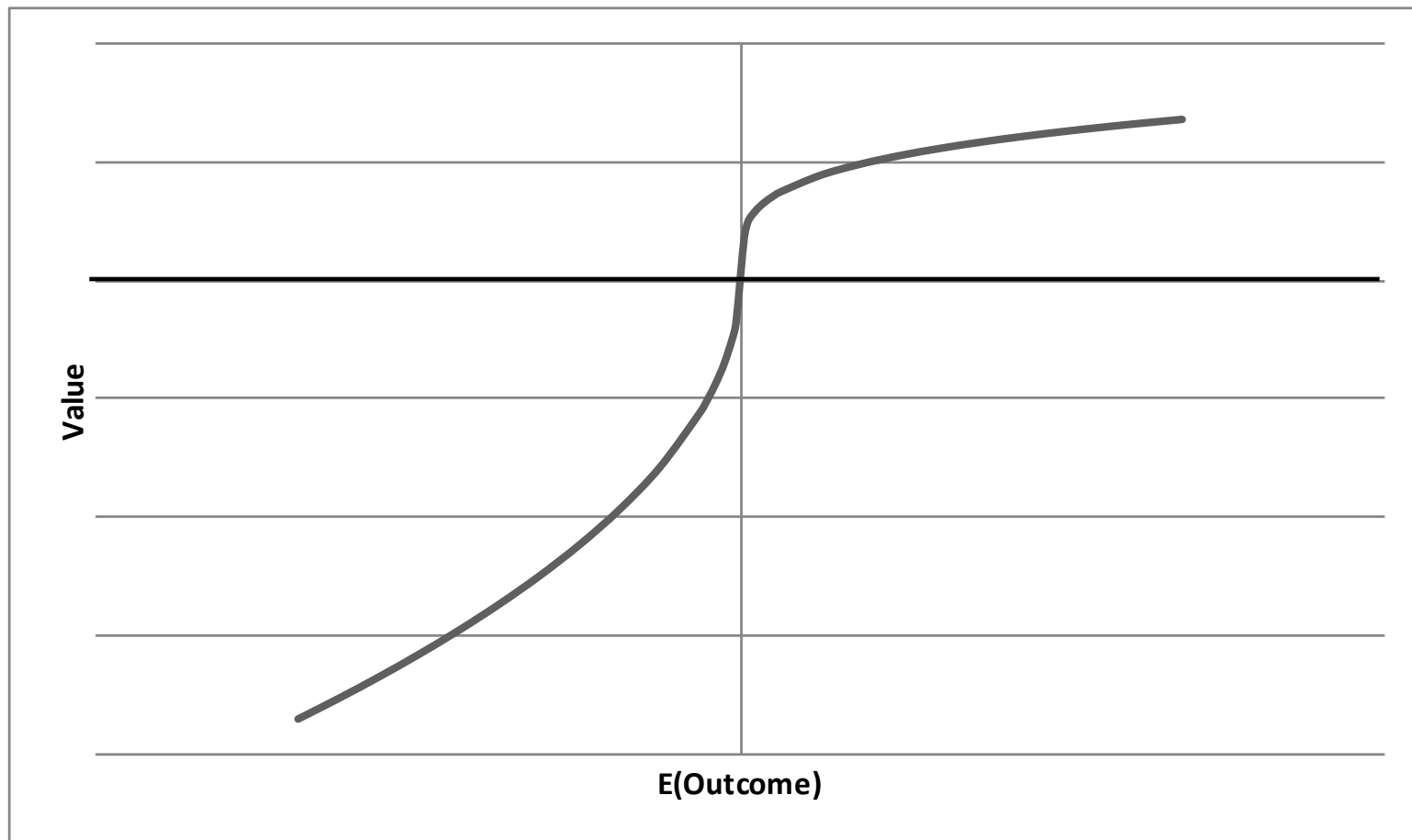
Prospect Theory – Properties of the Value Function

- The value function defines the values as deviations from a certain reference point.

- The decision maker is more sensitive to changes in outcome around the reference point.

- The decision maker is more sensitive to gaining a certain amount then to losing the same amount.

Prospect Theory – Experiment

Situation I

        Gamble A: sure win $400

        Gamble B: 50% probability of winning $1000

                          50% probability of winning $0

Situation II

        Gamble C: sure loss $400

        Gamble D: 50% probability of losing $1000

                          50% probability of losing $0

How would you decide in Situations I and II?

Prospect Theory – Experiment

- Prospective Theory: in situation I people choose A and in situation II people choose D.

- Prospective theory has two components:
    - Value function – which is similar to the utility function in utility theory.
    - Editing rule: the decision makers can manipulate, i.e. "edit", the choice problem until they arrive at different alternatives that can be easily compared.

- Edit rule: it has been shown that the same problem can be re-written in the frame of positive outcomes or negative outcomes leading to, respectively, risk-aversion and risk-seeking behaviour.

- These rules lead to significant problems in the analysis of risk from a normative perspective.

Characteristics of Risk and Risk Taking

- Volatility and Risk: A basic characteristic of risk is volatility.

- Ambiguity and Risk: People seem to be averse to risky choices when the probabilities are not specified. Ambiguity makes the use of normative approaches to risk more problematic.

- Risk Taking and Real Settings: In the real world risk analysis and management is a dynamic problem that is difficult to formulate as a statistical and quantitative problem.

Volatility and Risk

- The variance of a given distribution (e.g., stock prices) is a possible measure of risk.

- The use of variance to represent uncertainty is the corner-stone of the mean-variance approach in the Markowitz model.

- This approach suggests then when considering risky alternatives the decision maker should consider the expected value and the volatility (variance).

Volatility and Risk (Cont.)

- The Markovitch model suggests that when two alternatives have the same volatility the decision maker should choose the one with the highest expected value.

- The Markovitch model suggests that if an alternative A has higher volatility and expected value than an alternative B then the choice depends on the decision maker's risk attitude.

Ambiguity and Risk – Ellsberg's Experiment

- Suppose a game in which there are two bags, A and B.
  - Bag A contains 50 white and 50 black balls.
  - Bag B contains 100 balls but the number of white and black balls is undetermined.

- The decision maker must choose from which bag to draw the ball from and to guess the colour of ball picked up from the bag.

- If correct the decision gets $100 and if wrong it gets nothing. Which bag should the decision maker choose?

- Most people choose to draw the ball from bag A. This is the *ambiguity* effect.

Ambiguity and Risk – Ellsberg's Paradox

- Most people are indifferent to the choice of black or white from bag A and from bag B:
    - $W_A \sim B_A$
    - $W_B \sim B_B$

- Most people choose bag A:
    - $W_A \succ W_B$
    - $B_A \succ B_B$

- Contradiction: Most people choose bag A:
    - From $W_B \sim B_B$ implies that the decision maker believes the probabilities of both colours to be ½.
    - But from $W_A \succ W_B$ and $B_A \succ B_B$ it seems that the probability of W_B and B_B are both less than ½.

Risk Taking in Real Settings

- The formulation of the problem can be very difficult.

- The problems tend to be very dynamic.

- Risk taking by executives and other professionals suggests that we need to study risk analysis in practice.

- Three major concerns of decision makers in practice:
  - How is risk defined in a particular situation?
  - What are the decision maker's attitudes toward risk?
  - What can be done to manage risk?

Attitudes toward Risk in Management– Generic Aspects

- Risk taking attitudes of managers vary as a function of incentives and experience. In interviews to senior executives in an investment bank the follow characterization emerged:

    - Risk-seeking managers are perceived to be more innovative, to try to make changes and improve processes; they tend to be deal makers. They tend to be confident, outgoing and outspoken.
    - Risk-seeking individuals were also described as "messy", "aggressive", open-mouthed and egocentric.

    - Risk-averse managers were described as "chicken", nervous, unsecure, pessimistic, reserved, spineless, passive, slow, "yes men".

As a Manager is it better to be Risk-Seeking or Risk Averse?

- Risk aversion seems to be a good recipe to stay in the same organization. Risk-averse managers stay in the same company for many years and they are not confident they can get a better job than the one they have.

- Risk seeking individuals are either very successful or very unsuccessful. For one reason or another they tend to move up in the hierarchy or to other jobs.

- Some executives argued that young managers that want to be successful need to be risk prone in order to move up the ladder.

Attitudes toward Risk – Organizational Arrangements

- Organizations may have different arrangements for decision making, some of which are aimed to deal with risk taking (in order to limit risk exposure.)

- There is peer pressure to conform to certain types of behaviour, more or less risky, depending on the organization.

- Risk taking may lead to bonus and increase a person's reputation.

- Unsuccessful risk taking can lead to demotion, removal from one's job or even dismissal.

Cognitive Aspects of Risk Taking

- In the classical literature (mostly in finance) risk is defined as the volatility or associated to a given outcome.

- In management, however, managers conceive risk as the amount of money, reputation, or market share that is at jeopardy.

- In management, it is the lower part of the distribution that represents risk.

Cognitive Aspects of Risk Taking - II

- Individuals do not trust, use or understand the meaning of probability estimates.

- Individuals tend to exclude events that have a very small probability of happening (disasters or major discoveries) from their calculations.

- In industries where there are many events with very low probability but high impact (e.g., pharmaceutical companies) if the company does not prepare for these events it is not prepared for the future.

Summary

- Risk is an important part of business. We discuss the importance of risk management for the firms.

- We analyze how risk attitudes lead to different decisions for the same problem, using the same data.

- We discuss prospect theory and cognitive issues in risk taking.