Risk and Uncertainty

- Risk
  - Lack of certainty about future outcomes. The exact outcomes are known, but the probabilities of alternative outcomes are known
- Uncertainty
  - Greater lack of certainty about future outcomes. The range of possible outcomes, and the probabilities of future outcomes are all unknown

Analysis of Risk

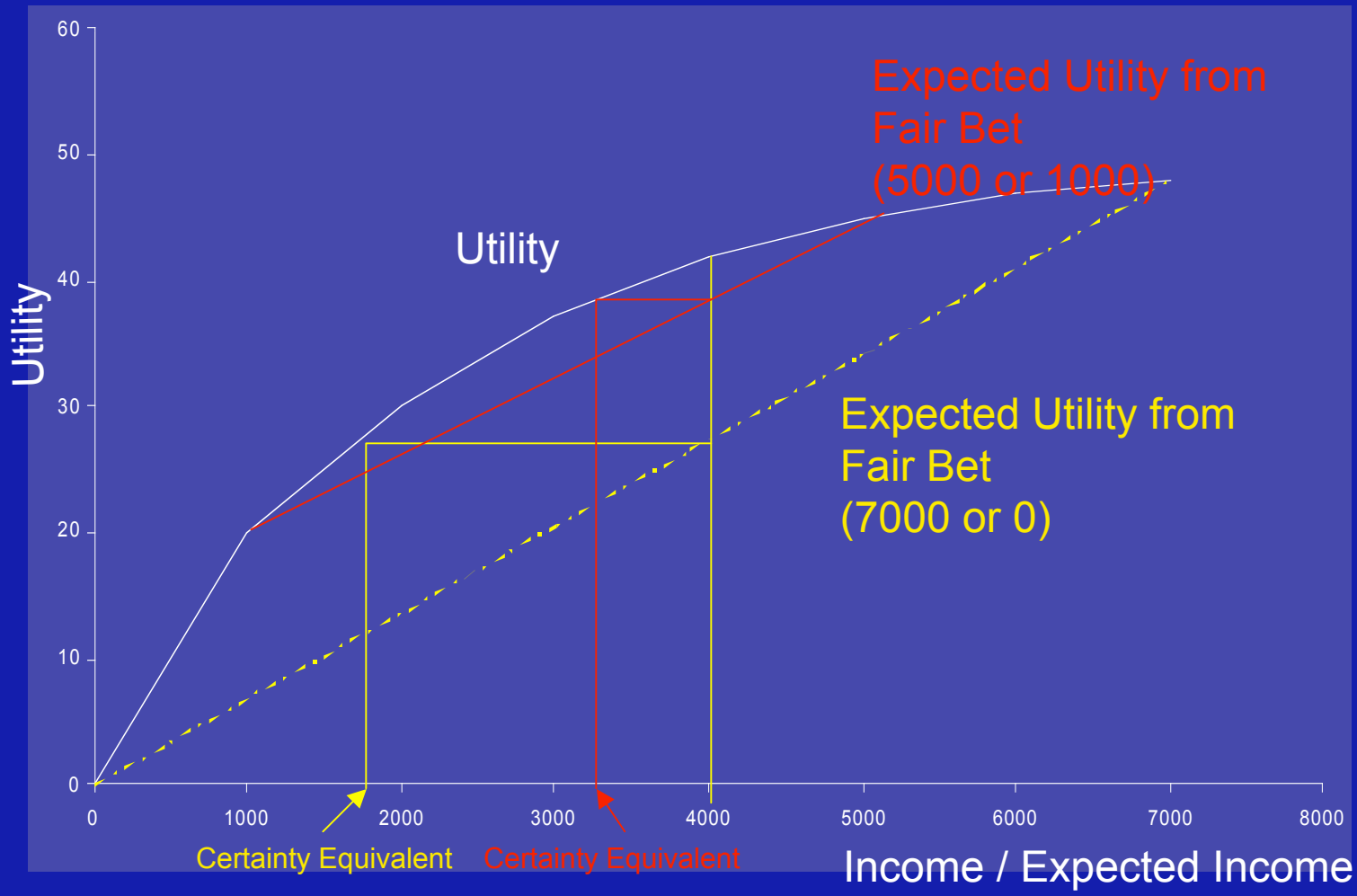
- Risk – Outcomes are unknown, but can estimate probabilities of different outcomes
  - Contingencies x_i (possible States of the world)
  - Probabilities p_i
    - $0 \leq p_i \geq 1$
    - $\_i(p_i) = 1$
  - Expected outcome (Expected Value):
  - $\_i(p_i * x_i)$

Analysis of Risk

- Expected Values of Net benefits under all contingencies
  - $\sum_i p_i * (B_i - C_i)$
  - Need to make sure that contingencies and associated probabilities are appropriately identified.
    - *Spreadsheet example*

Analysis of Risk

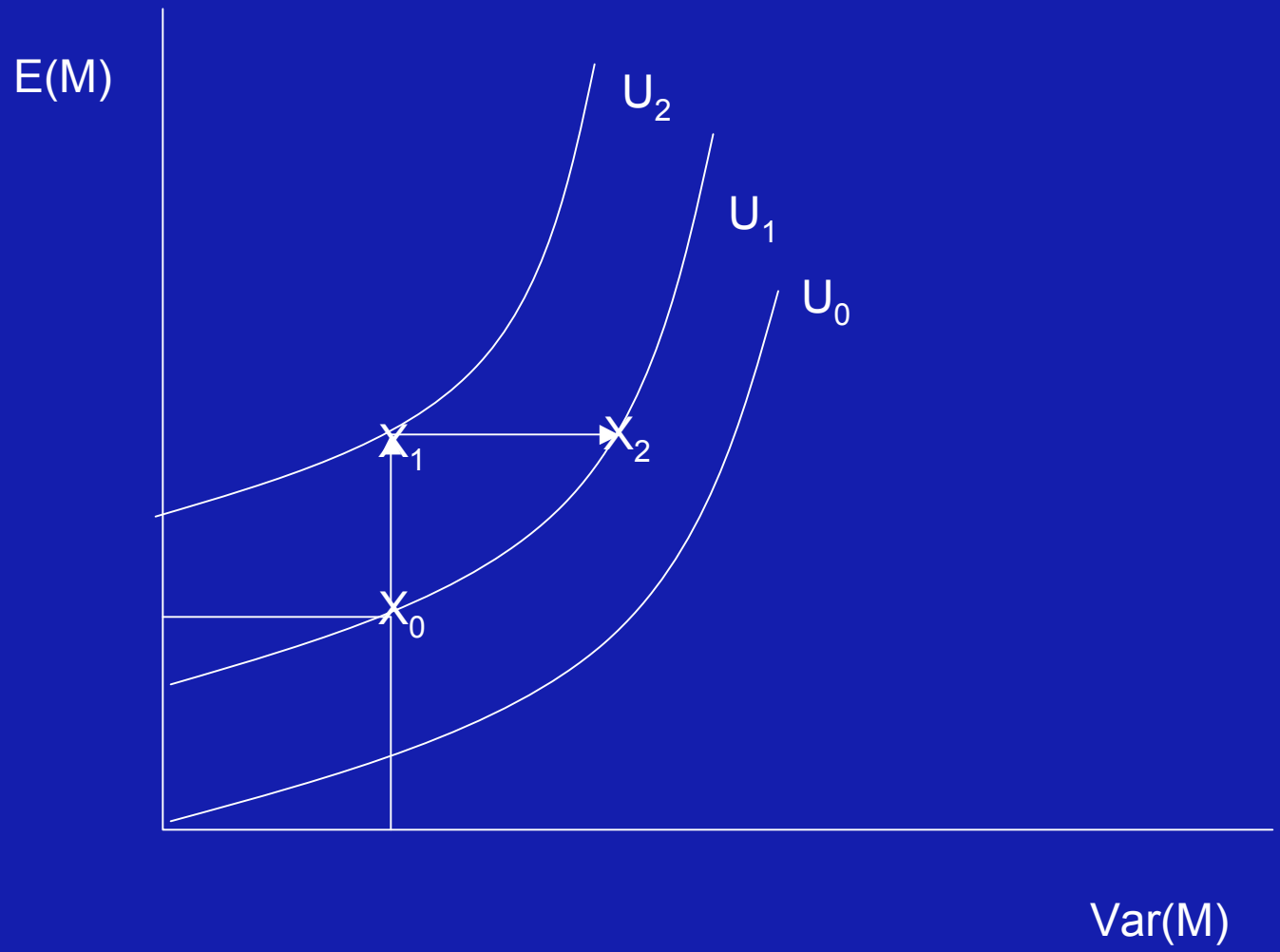
- Projects may increase or decrease level of risk that individuals face
- Risk aversion of individuals
  - $\partial U/\partial M < 0$ (Diminishing Marginal utility of Money)
  - Compare expected utility from fair bets with certain income
    - *Spreadsheet examples*


Utility
60
50
40
30
20
10
0
0
1000
2000
3000
4000
5000
6000
7000
8000
Utility
Expected Utility from Fair Bet (5000 or 1000)
Expected Utility from Fair Bet (7000 or 0)
Certainty Equivalent
Certainty Equivalent
Income / Expected Income

Analysis of Risk

- EU = EU{E(M) , Var(M)}
  - $\delta EU/\delta E(M) > 0$
  - $\delta EU/\delta Var(M) < 0$
- $Var(M) = \sum_i (M_i - M)^2 / (1 - N)$
  - M = mean of M_i
  - N = sample size

Indifference curves of Mean and Variance of Expected Income (M)



Analysis of Risk

- So:
  - Need to take into consideration effects of project on variance of income. (effect on risk)
  - If project increases variance of possible outcomes, this should be discounted from benefits
  - Some projects reduce variations of possible outcomes

Analysis of Risk

- Example: Irrigation project
  - Increases expected return, but also increases variability of return
  - Increases probability of loss

Analysis of Risk

- Traditional system
  - Cost: $10
  - Returns: 50% chance of $12
    50% chance of $14
  - Profits: 50% chance of $2
    50% chance of $4
  - Expected profit: .5 (2) + .5 (4) = $3

Analysis of Risk

- Irrigation system
  - Cost: $30
  - Returns: 50% chance of $12
    50% chance of $80
  - Profits: 50% chance of $18 loss
    50% chance of $50 profit
  - Expected profit: .5 (-18) + .5 (50) = $16

Analysis of Risk

- Comparison of systems:
- Traditional system:
  - Expected profit = $3
  - Variance = 1
- Irrigated system:
  - Expected profit = $16
  - Variance = 2,312
  - AND 50% CHANCE OF LOSSES

Risk and Uncertainty

- Uncertainty
  - Future outcomes unknown, and probabilities of alternative outcomes are unknown
  - Appropriate analytical tool do address uncertainty – Sensitivity analysis
  - Vary assumptions in analysis, to see how much the results change
  - This is an area where “art” enters into CBA. Good sensitivity analysis requires thinking creatively about possible outcomes that could dramatically alter the results based on the “expected” outcomes