This Week

Monday

- Decision Making with Uncertainty

Wednesday

- Lab Exercise: Health Insurance Comparison

Topics

- **Decision Making with Well-Defined Outcomes**
- **Dealing with Not-So-Well-Defined Outcomes**
  - **Continuous Outcomes**
  - **Unknown Outcome Probabilities**

A Problem Solving Framework

1. *Define the Problem*
2. *Collect and Organize Data*
3. *Characterize Uncertainty and Data Relationships*
4. *Build an Evaluation Model*
5. *Formulate a Solution Approach*
6. *Evaluate Potential Solutions*
7. *Recommend a Course of Action*

Decision Making With Well-Defined Outcomes

Given:

- The set of *decision alternatives*
- The possible *outcomes* of the sources of uncertainty
- The associated *probabilities* of each outcome

We need to determine:

- What are the *consequences* for each possible combination of decision alternative and outcome?
- How should we *measure* the decision alternatives?
- What is the *best* decision alternative?

Health Insurance Decision Problem

Four different health insurance policies to consider:

	Health Insurance Plans			
	Plan1	Plan2	Plan3	Plan4
Annual Premium:	$600	$900	$1,500	$0
Deductible:	$200	$100	$0	$0
Co-insurance:	20%	10%	0%	100%
Out-of-Pocket Limit**:	$2,500	$1,500	$0	

*** Exclusive of annual premium***

Annual Health Care Expenses (to nearest $100): $600

One possible outcome

Total Annual Cost to Individual Under Each Plan			
Plan1	Plan2	Plan3	Plan4
$880	$1,050	$1,500	$600

And its consequences

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Deductible:	$200	$100	$0	$0
Co-insurance:	20%	10%	0%	100%
Out-of-Pocket Limit**:	$2,500	$1,500	$0	

*** Exclusive of annual premium***

Annual Health Care Expenses (to nearest $100): $5,000

Another outcome

Total Annual Cost to Individual Under Each Plan			
Plan1	Plan2	Plan3	Plan4
$1,760	$1,490	$1,500	$5,000

And its consequences

Enumerating the Consequences

A ***payoff table*** lists the ***consequences*** (usually $) for each possible combination of decision alternative and outcome.

Possible Values for Annual Health Care Expenses	Total Annual Cost to Individual Under Each Plan			
	Plan1	Plan2	Plan3	Plan4
$0	$600	$900	$1,500	$0
$200	$800	$1,010	$1,500	$200
$600	$880	$1,050	$1,500	$600
$1,000	$960	$1,090	$1,500	$1,000
$2,000	$1,160	$1,190	$1,500	$2,000
$5,000	$1,760	$1,490	$1,500	$5,000
$10,000	$2,760	$1,990	$1,500	$10,000
$15,000	$3,100	$2,400	$1,500	$15,000
$25,000	$3,100	$2,400	$1,500	$25,000
$50,000	$3,100	$2,400	$1,500	$50,000

All Possible Outcomes

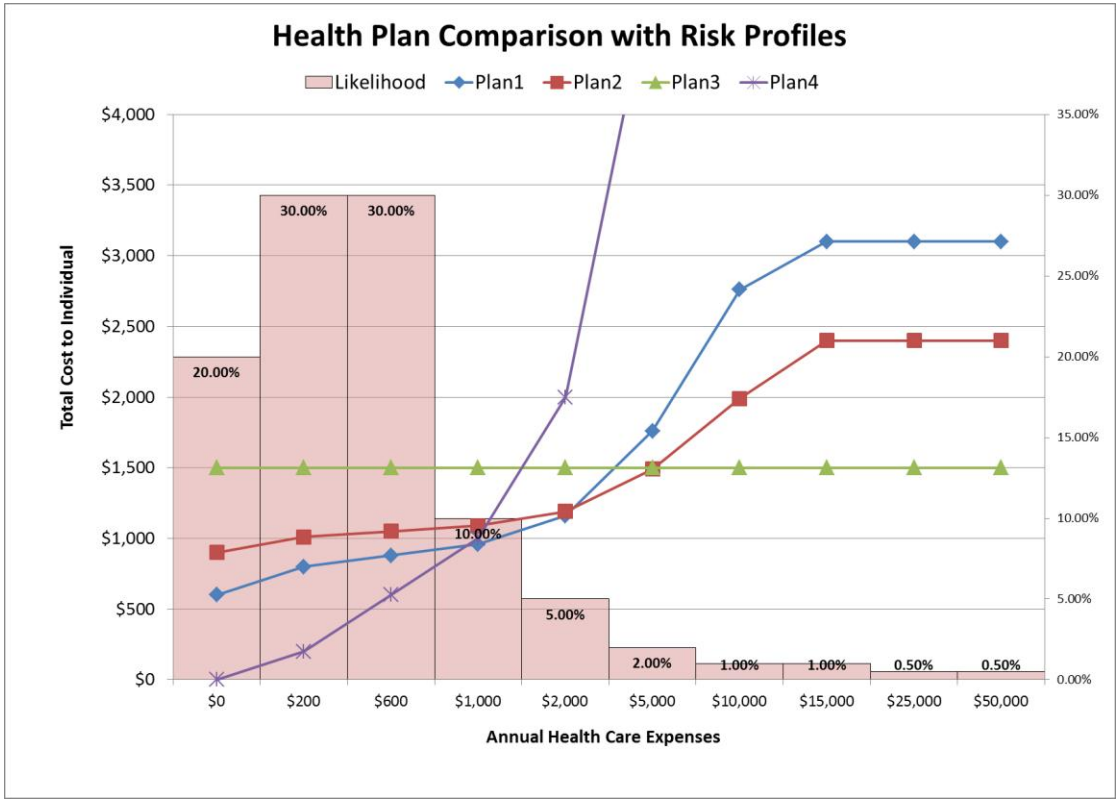
Consequences for Plan1

Consequences for Plan4

Assessing Risk

- The ***risk profile*** for a decision alternative describes the ***probability distribution of its consequences*** (i.e., the likelihoods that the payoff table entries will be realized).

Likelihood of Each Expense Level	Possible Values for Annual Health Care Expenses
20.00%	$0
30.00%	$200
30.00%	$600
10.00%	$1,000
5.00%	$2,000
2.00%	$5,000
1.00%	$10,000
1.00%	$15,000
0.50%	$25,000
0.50%	$50,000



One Possible Decision Rule

The ***expected monetary value*** (**EMV**) of a decision alternative is the ***expected payoff of the alternative***.

Likelihood of Each Expense Level	Possible Values for Annual Health Care Expenses	Total Annual Cost to Individual Under Each Plan			
		Plan1	Plan2	Plan3	Plan4
20.00%	$0	$600	$900	$1,500	$0
30.00%	$200	$800	$1,010	$1,500	$200
30.00%	$600	$880	$1,050	$1,500	$600
10.00%	$1,000	$960	$1,090	$1,500	$1,000
5.00%	$2,000	$1,160	$1,190	$1,500	$2,000
2.00%	$5,000	$1,760	$1,490	$1,500	$5,000
1.00%	$10,000	$2,760	$1,990	$1,500	$10,000
1.00%	$15,000	$3,100	$2,400	$1,500	$15,000
0.50%	$25,000	$3,100	$2,400	$1,500	$25,000
0.50%	$50,000	$3,100	$2,400	$1,500	$50,000
Expected Annual Cost of Plan:		$902.80	$1,064.20	$1,500.00	$1,165.00

Questions to Consider

Which plan would you choose, and why?

- Is Plan1 the “best” plan?
- Under what circumstances would choosing each plan make sense?
- In any given year, what is the probability that Plan1 will be the ***lowest cost plan***? Plan2? Plan 3?
- In any given year, what is the probability that your ***total cost will exceed $1000*** under each plan?

Comparing Decision Alternatives

Here are some commonly used decision rules when risk profile information is available (i.e., when consequence probabilities are ***known*** for each alternative)**:**

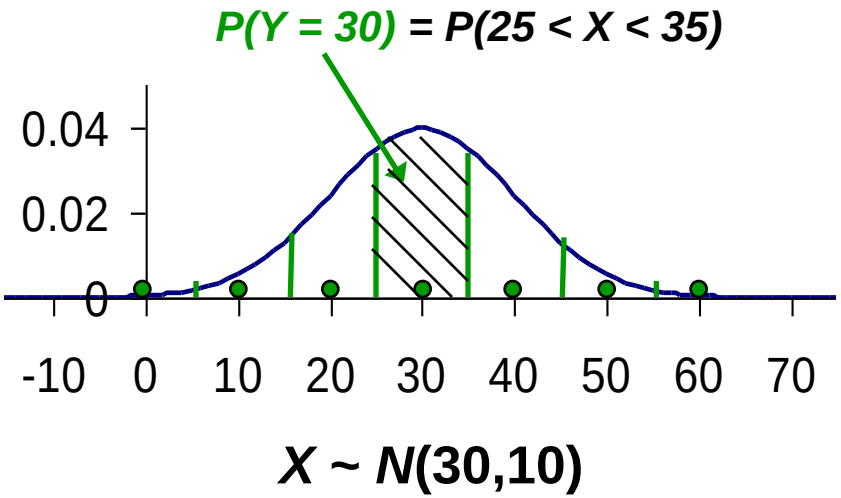
- ***Highest (Lowest) EMV***
- ***Highest (Lowest) EMV subject to other constraints***
  - e.g., *P*(Total Cost > $2500) = 0%
- ***Lowest (Highest) probability of monetary consequences exceeding a certain value***
  - e.g., Choose alternative with lowest *P*(Total Cost > $1,500)
- ***Highest Expected Utility***
  - ***Utility values*** incorporate ***attitudes toward risk*** and are used in place of monetary consequences for evaluation.

Not-So-Well Defined Outcomes

- **Continuous Outcomes**
- **Unknown Outcome Probabilities**

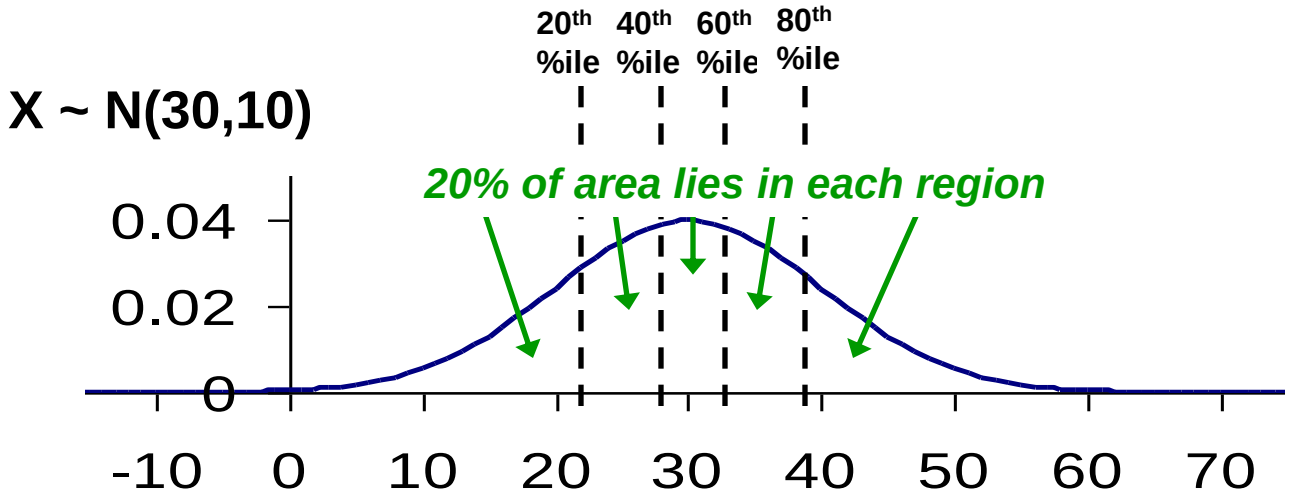
Evaluating Continuous Outcomes

- When a source of uncertainty is a ***continuous*** random variable, it is impossible to list ***all*** possible outcomes for evaluation purposes.
- A common practice is to use a ***discrete approximation*** to the continuous distribution.
- Approximation using ***midpoints of fixed-length value ranges***:

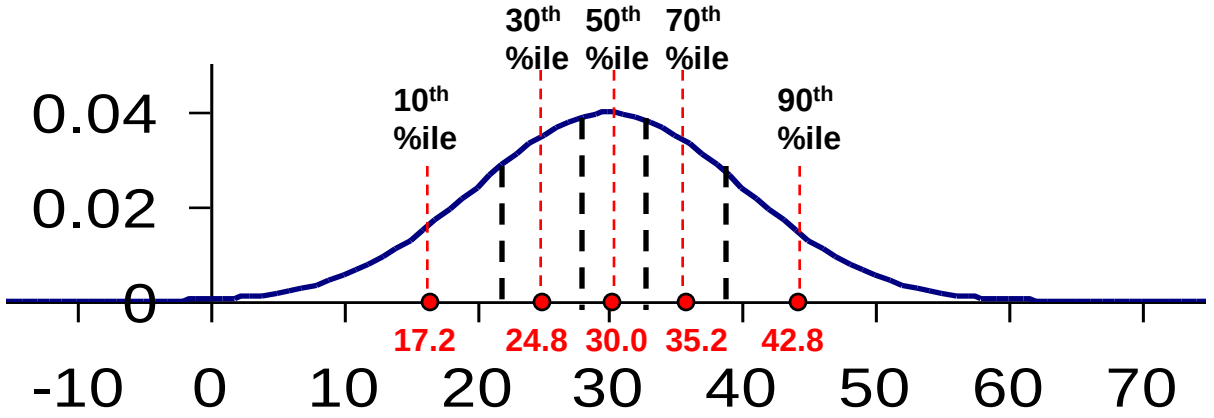


Evaluating Continuous Outcomes

- Approximation using ***midpoint percentiles***:



P(X = 17.2) = 20%
P(X = 24.8) = 20%
P(X = 30.0) = 20%
P(X = 35.2) = 20%
P(X = 42.8) = 20%



Unknown Outcome Probabilities

What can we do if the outcome probabilities are ***unknown***?

Likelihood of Each Expense Level	Possible Values for Annual Health Care Expenses	Total Annual Cost to Individual Under Each Plan			
		Plan1	Plan2	Plan3	Plan4
?	$0	$600	$900	$1,500	$0
?	$200	$800	$1,010	$1,500	$200
?	$600	$880	$1,050	$1,500	$600
?	$1,000	$960	$1,090	$1,500	$1,000
?	$2,000	$1,160	$1,190	$1,500	$2,000
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?	$10,000	$2,760	$1,990	$1,500	$10,000
?	$15,000	$3,100	$2,400	$1,500	$15,000
?	$25,000	$3,100	$2,400	$1,500	$25,000
?	$50,000	$3,100	$2,400	$1,500	$50,000

Comparing Decision Alternatives

Here are some commonly used decision rules when consequence probabilities are ***unknown****:

- ***Laplace Rule***: Assume that ***all outcomes are equally likely*** and select the alternative with the ***highest EMV***.
- ***Maximin Rule (minimax for costs)***: Select the alternative with the ***highest "worst" payoff value*** (over all possible outcomes).
- ***Maximax Rule (minimin for costs)***: Select the alternative with the ***highest "best" payoff value*** (over all possible outcomes).
- ***Minimax Regret Rule***: Select the alternative such that the ***maximum "regret" over all possible outcomes is minimized***. The ***regret*** of an alternative for a particular outcome is the difference between the alternative payoff and the best payoff for that outcome.

***from Engineering Economy, Ninth Edition,Thuesen & Fabrycky, 2001.**