Decision Making

BUS 735: Business Decision Making and Research

Goals of this section

- Specific goals:
  - Learn how to conduct regression analysis with a dummy independent variable.
- Learning objectives:
  - LO5: Be able to use stochastic operations research models to answer business questions that involve uncertainty.
  - LO7: Have a sound familiarity of various statistical and quantitative methods in order to be able to approach a business decision problem and be able to select appropriate methods to answer the question.

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Decision Making Without Probabilities

- Suppose you have to decide on one of three choices for your business:
  1. Expand facilities.
  2. Renovate existing facilities.
  3. Do nothing.
- Each have costs (known) and benefits (unknown).
- Suppose profits depend on economic conditions:

Decision	Good Economic Conditions	Bad Economic Conditions
Expand	\$150,000	-\$10,000
Renovate	\$90,000	\$10,000
Do nothing	\$70,000	\$40,000

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Maximax Decision

- Problem: probabilities of having good economic conditions or bad economic conditions are unknown.
- Maximax Decision:
  - Compute the best (maximum) outcome for each choice (very optimistic).
  - Choose the maximum of the best outcomes.
  - Choosing options given best-case scenarios.

Decision	Good Economic Conditions	Bad Economic Conditions	Maximum
Expand	\$150,000	-\$10,000	\$150,000
Renovate	\$90,000	\$10,000	\$90,000
Do nothing	\$70,000	\$40,000	\$70,000

- Maximum of maximums = \$150,000. Choice = Expand!

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Renovate	$90,000	$10,000	$10,000
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Minimax Regret Decision

- **Regret** is the difference between the payoff of a given decision and the best decision under a given scenario.
- Example: Suppose you chose to *do nothing* and there ended up being good economic conditions.
  - Best decision given good economic condition is to *expand*. Profit = $150,000.
  - Profit from *doing nothing* given good economic condition is $70,000.
  - Regret = $150,000 - $70,000 = $80,000.
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  - Compute regrets for every cell in table..
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- Regrets Table:

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Do nothing	$80,000	$0	$80,000

- Minimum of maximum regrets = $50,000. Choice = Expand!

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Equally Likely Decision

- Suppose (for no reason whatsoever) that each outcome is equally likely.
- Compute weighted average of each decision (with equal weights).
- P(Good Economic Conditions) = P(Bad Economic Conditions) = 0.5.
- Equal Likelihood Table:

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Hurwicz Decision

- Take a weighted average again, but choose an arbitrary weight for the best-case value.
- Coefficient of optimism, given by α, is a measure of the decision makers optimism.
- Best-case weight $= \alpha$, worst-case weight $= (1 - \alpha)$.
- Suppose $\alpha = 0.2$ (very arbitrary).

Decision	Good Economic Conditions	Bad Economic Conditions	"Expected" Value
Expand	$150,00	-$10,000	$22,000
Renovate	$90,000	$10,000	$26,000
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Dependence on Optimism

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- Optimal choice might vary a lot depending on this parameter.
- For each pair of decisions, find the cut-off value of α that leads one to switch decisions.

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Summary of Results

Criterion	Decision
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Maximin	Do nothing
Minimax Regret	Expand
Equal Likelihood	Expand
Hurwicz ($\alpha = 0.2$)	Do nothing

- **Dominant decision:** when same choice is made for every criterion considered.
- **Dominated decision:** when choice is never made for every criterion considered.

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Expected Values: Probabilities Known

- Suppose probabilities for good economic conditions and bad economic conditions are known.
- Suppose P(Good Economic Conditions) 0.6, P(Bad Economic Conditions) = 0.4.

Decision	Good Economic Conditions	Bad Economic Conditions	Expected Value
Expand	$150,00	-$10,000	$86,000
Renovate	$90,000	$10,000	$58,000
Do nothing	$70,000	$40,000	$58,000

- Maximum expected value = $86,000. Decision = Expand!
- A **risk neutral** decision maker should make this decision.

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Expected Opportunity Loss

- **Expected opportunity loss (EOL)** = expected value of regret for each decision.
- Regrets Table:

Decision	Good Economic Conditions	Bad Economic Conditions	Expected Value
Expand	\$0	\$50,000	\$20,000
Renovate	\$60,000	\$30,000	\$48,000
Do nothing	\$80,000	\$0	\$48,000

- Minimum expected regret = \$20,000. Decision = Expand!
- Minimum expected loss decision *will always be equal to* maximum expected value decision.

Expected Opportunity Loss

- **Expected opportunity loss (EOL)** = expected value of regret for each decision.
- Regrets Table:

Decision	Good Economic Conditions	Bad Economic Conditions	Expected Value
Expand	\$0	\$50,000	\$20,000
Renovate	\$60,000	\$30,000	\$48,000
Do nothing	\$80,000	\$0	\$48,000

- Minimum expected regret = \$20,000. Decision = Expand!
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Expected Value of Perfect Information

- Suppose you could purchase "perfect information" about what will happen. How much would you pay?
- If you were told good economic conditions:
  - Decision = Expand, Profit = \$150,000.
- If you were told bad economic conditions:
  - Decision = Do nothing, Profit = \$40,000.
- A priori expected profit (given you will make a perfect decision):
  - Expected Profit = (0.6)(\$150,000) + (0.4)(\$40,000) = \$106,000.
- Expected profit from maximizing expected value = \$86,000.
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Bayesian Analysis

- **Bayesian analysis:** decision making using additional information which alter conditional probabilities.
- Suppose P(good economic conditions), P(bad economic conditions) are simply based on past history.
- Suppose your the Minneapolis Federal Reserve Bank issues an economic report (which they do) that indicates whether they have a positive economic outlook or a negative economic outlook.
- This is useful information, but not *perfect information*.
- Define the following events:
  - P: positive economic report.
  - N: negative economic report.
  - G: Good economic conditions.
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- Of course, P(P) = 1 - P(N), P(G) = 1 - P(B).

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- Suppose past experience indicates the Federal Reserve report accurately forecasts...
  - good economic conditions 80% of the time, and
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  - $P(P|g) = 0.8$, $P(N|g) = 0.2$.
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- Suppose a positive report came out. We want to know $P(g|P)$:

$$P(g|P) = \frac{P(g \cap P)}{P(P)} = \frac{P(P|g)P(g)}{P(P|g)P(g) + P(P|b)P(b)}$$

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Compute Conditional Expected Values

- Now use $P(g|P)$ and $P(b|P)$ to find decision that maximizes expected value. What is the expected value?
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